COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. XIII MARCH, 1908 No. 3

PLACE'S AIR-LIQUEFYING EXPANSION ENGINE

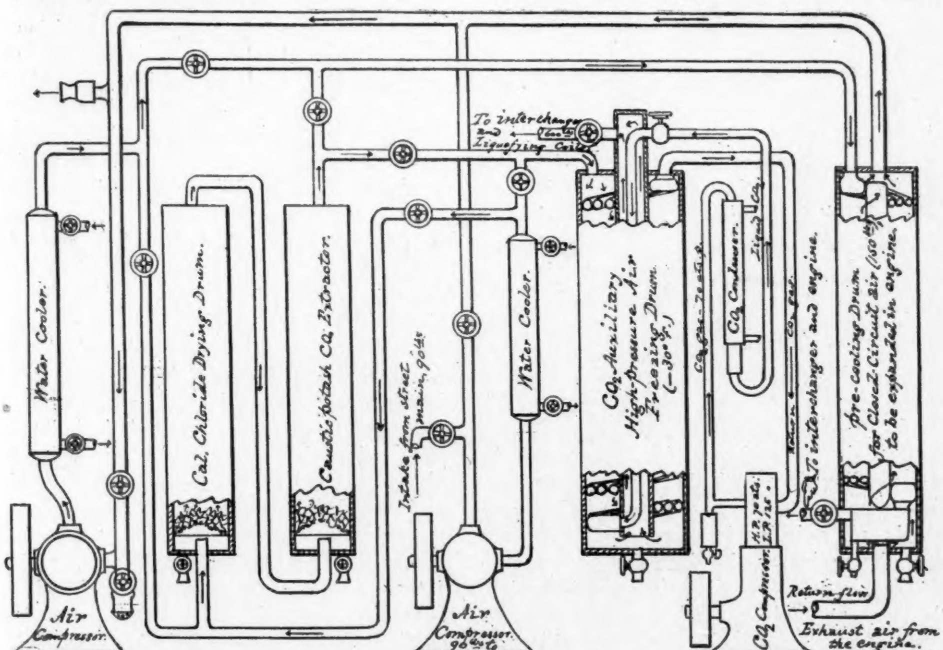
Some Indicator Cards Taken at Low Temperatures from the Air Expanding Engine of the Air-liquefying Plant at Norwich, Conn.

By J. F. Place, M. E.

Having recently completed and put into successful operation an air-liquefying plant for the New England Refrigerating Co., at Norwich, Conn., based on my process of liquefying air by the refrigeration produced by expanding air in an insulated air-expansion engine, I find myself in possession of several hundred indicator cards taken from the engine during the time of experimentally testing it and perfecting the other air-liquefying apparatus erected in connection therewith.

Some of these cards will no doubt be of interest to mechanical engineers familiar with this branch of thermo-dynamics, or with refrigerating machinery generally, and I have therefore made a few selections for publication.

It would be well, perhaps, as a premise to the exhibition of these cards, to give a brief



The N. E. Refrigerating Co.'s Air-liquefying Plant at Norwich, Conn., U. S. A.
(Place's Patent Expansion Engine System.)

FIGURE I.

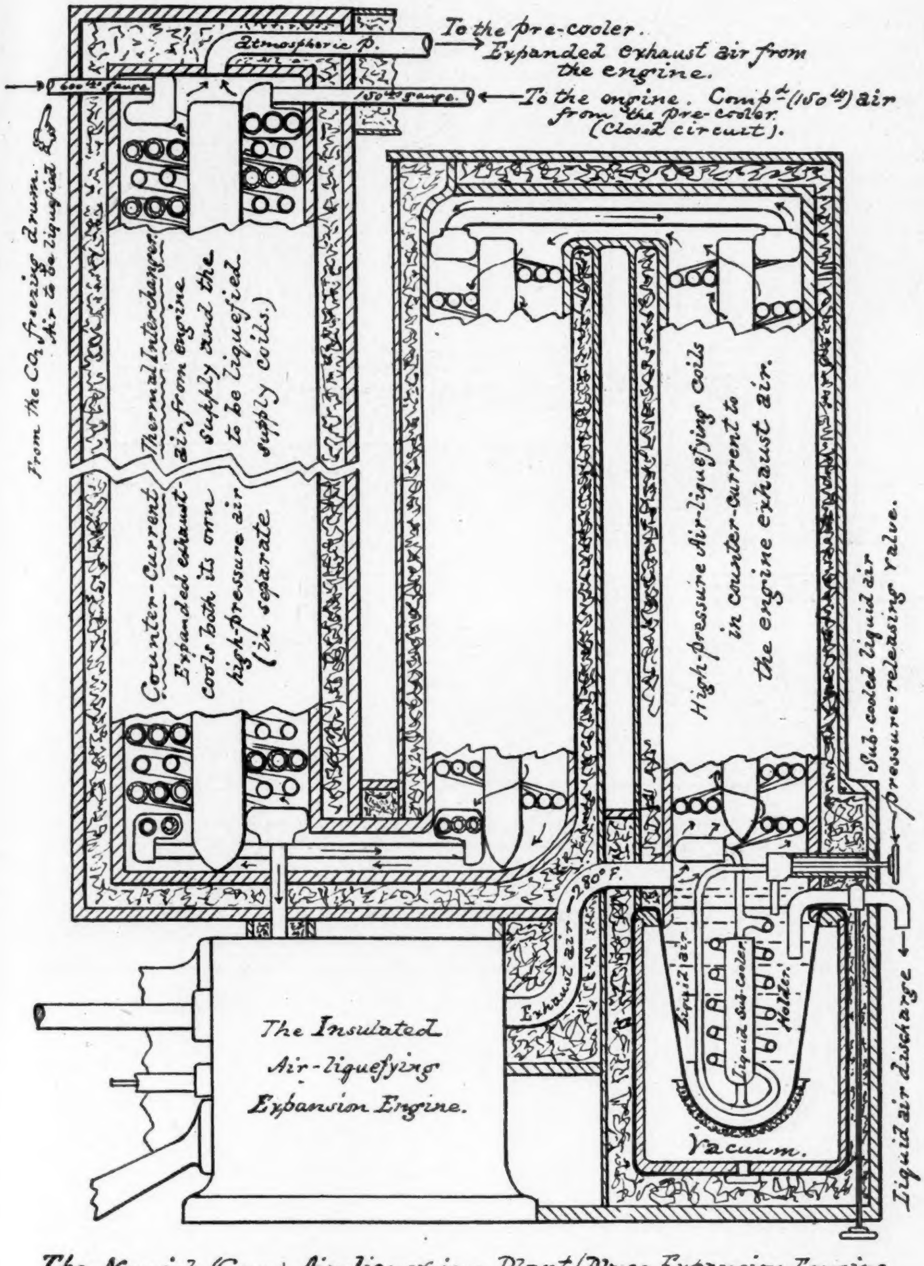
description of the engine and its accessory air-liquefying apparatus.

Besides the air-expansion engine, the plant (shown diagrammatically in Figs. 1 and 2) consists of an 8x8 inch air-compressor; moisture and carbonic acid extracting drums; a small CO_2 refrigerating system, comprising a 3 horse-power compressor, condenser and freezing air-drum; a high-pressure still-air liquefier, with submerged liquid-air sub-cooling tank; and a small high-pressure air compressor to supply the liquefier. The air in this case is taken from the street main of the Norwich Compressed Air Power Co., which is usually at 85 pounds, gage, and is run through a lime drum into the 8x8 inch air compressor, and compressed to between 160 pounds and 180 pounds, gage. This compressor is driven by a 9x9 inch upright engine, which is operated by compressed air from the street main. From the 8x8 inch compressor the compressed air of 160 to 180 pounds is conducted through cooling pipes laid in the Shetucket river close by, and is then passed, successively, through a calcium chloride drum and a caustic potash drum, and the freezing drum of the small CO_2 system; and thence into coils through a pre-cooling drum. It then enters the engine supply coils of the counter-current thermal interchanger, where it is cooled by the outflowing expanded exhaust air from the engine to a temperature of about —180° to —210°, and is then delivered to the valve chamber of the same air-expanding engine.

The cold, expanded exhaust air from the engine (at 260° to 300° Fahr. below zero), is conducted first over the high-pressure compressed-air liquefying coils, composing the still-air liquefier; and then over both these liquefying coils and the compressed-air engine supply pipes in a single conduit; and then over the engine supply pipes alone in the pre-cooling drum. From here it is discharged to the open atmosphere; and so complete is the transfer of heat in the system that this surplus air discharged to the open, is rarely more than a degree or so below the temperature of the water-cooled compressed air entering the engine supply coils of this pre-cooler.

The air for the liquefying coils is taken from the engine supply pipe, after water cooling, and is compressed to 42 atmospheres, and after being water-cooled is passed in pipes through the exhaust air cooling conduit to the liquefying coils. A compressor is being put in to take the air at atmospheric pressure and compress it to 85 pounds to supply the 8x8 compressor, and then, after the compressed air being supplied to the engine is thoroughly dry, the chemical drums and the CO_2 freezing drum will be cut out, and this air for the engine will be worked in a closed circuit; and the air supplied to the liquefying coils (at 600 pounds) will be passed through those drums before entering the interchanger, on its way to be liquefied.

The air-expanding engine is 6⅝x10 inch stroke, of the horizontal, double-acting reciprocating type. The cylinder is overhung, projecting from the frame which forms the crosshead slides, and is suspended on eight hollow tubes of fibre, which pass through two strong fibre slabs, 1¼ inch thick, which hold the cylinder heads against lead gasket packings firmly in place. Within these fibre tubes (or supporting hollow beams) are encased long insulated steel tie-bolts, ¾x40 inches, the whole being firmly drawn up against oak thimbles, 3 inches diameter (which enclose the fibre tubes), home against the face of the overhung cross-head frame. In this way the cylinder projects about 30 inches beyond the frame, and is not allowed contact with anything, so that no heat can be conducted to any of its parts to neutralize refrigeration. The whole cylinder is thoroughly insulated from the normal heat of the outside atmosphere, first by matched wood-lagging, made air-tight by shellac, then by a packing of eiderdown 4 to 5 inches thick, enclosed in canvas (made air-tight by shellac), and covered, including the ends, with nickel foil, which gives it all a highly polished surface; and outside of this a packing of 6 inches of fine washed wool, all around and over the ends, the whole being enclosed in shellac-treated canvas, and an outer matched-wood lagging, varnished; the piston-rod and main valve stem being enclosed in fibre sleeves about 18 inches long, which pass through the various insulations. These sleeves have brass-mounted fibre stuffing boxes on the outer ends, and both piston-rod and main valve rod are packed with dry braided flax and cup-leather packing. These stuffing boxes, although fully 16 inches from the cylinder, are always frost covered when the engine is running; but the rods run therein without lubrication, almost frictionless, and perfectly air-tight.



The Norwich (Conn) Air-liquefying Plant (Place Expansion Engine System). Diagram showing arrangement of the counter-current cooling coils, the engine, the liquefying coils, vacuum-jacketed liquid sub-cooler, &c.

FIGURE 2.

A NOVEL CUT-OFF.

The valve is of most novel construction—my own design, after many costly experiments. It is substantially a balanced Meyer variable cut-off, of the cylindrical piston type, exhausting over the outer ends. The cut-off valves (running inside the main valve) are arranged to cut off by the inner edge of each valve, thus insuring a much sharper cut-off than the ordinary type of Meyer valve; as when the air is cut off the main valve and cut-off valves are traveling in opposite directions, and at their greatest velocity. The main valve is given ⅜ inch air lap and $\frac{1}{16}$ inch exhaust lap, and set with a lead of 6 degrees. The travel of the valve is 2 inches for main valve and 1¾ inches for cut-off valve. The main valve eccentric is set 63 degrees in trail of the crank, and the cut-off valve eccentric 55 degrees in advance of the crank.

The cut-off valve stem is enclosed inside the main valve rod, both being of steel, of minimum cross-sectional area, and 50 inches and 30 inches long, respectively. The main valve rod is of course tubular, and is lined throughout with a bronze graphite-ring packed lining, forced in. The cylinder is of cast iron and has a seamless drawn steel lining, carefully machined and ground in place and highly polished; the main valve also runs in a similar lining. As the temperature of both cylinder and valve is from —200° F. to —310° F. all the time, of course no lubrication is used. After the trial of various metals and alloys, and many other substances, I found that leather and ordinary red paper fibre are the least affected by the extremely low temperatures I had to deal with. I found that friction of the piston or valves, at even these low temperatures, or leakage of either one, if allowed, would neutralize considerable of the refrigeration I sought; it was therefore absolutely essential to success that internal friction should be practically eliminated, and that both the piston and valves should run air-tight. After many experiments with iron, bronze, fibre, raw-hide and other ring packing, I finally adopted cup-leather packings, both for piston and main valve, and fibre-ring packing for the cut-off valves. They give no trouble—run, apparently, just as easily and smoothly, and are equally as effective at 310° below zero as at 60° above; and are absolutely air-tight at all times with an initial working pressure of 180

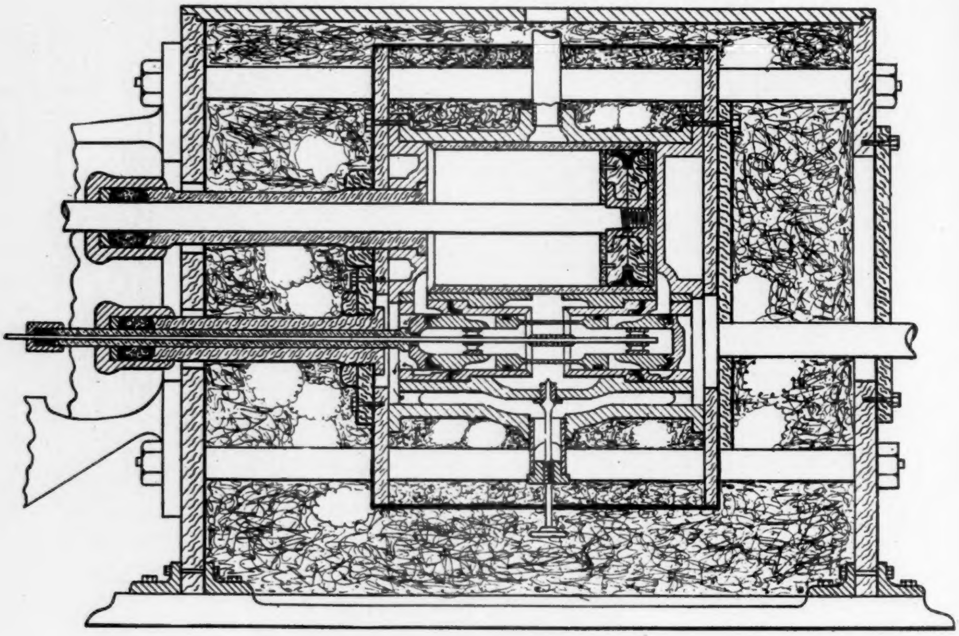


FIG. 3—INSULATED ENGINE CYLINDER OF PLACE'S AIR-LIQUIFYING EXPANSION ENGINE.

pounds gage. There is much less friction at these very low temperatures than there is at normal temperature.

The piston is of fibre (which runs with little or no friction on polished steel at low temperatures) held together by bronze collars, and made about .002 inch smaller in diameter than the inside diameter of cylinder. A disk cap of fibre on each side of the piston insulates the bronze collars from the air charge. This was found necessary to prevent loss by heat passing through the piston. The leather cups are in the centre, back to back, and held up to their work by a V-shaped bronze ring between them, make .004 inch smaller diameter than the cylinder bore, so as not to come in contact with the walls thereof. The leather cup packing practically takes the wear, and actually holds the piston in the centre of the bore, away from the cylinder walls on all sides. The sketch herewith (Fig. 3) shows the engine cylinder and valve in longitudinal vertical section.

The designing of the valve with cup-leather packing rings was a problem of extreme difficulty, on account of the annular ports in both valve and valve-chamber lining. The enlarged sketch (Fig. 4), however, shows how this was accomplished. The valve is made a very trifle smaller in diameter than the liner in which it operates, so that the wear is taken by the cup-leather packing; but great care had to be given to this point, otherwise there would be leakage immediately preceding admission and release.

Of course the exhaust air from the engine is carried back over the compressed air, being supplied to it for expansion therein. The liquefier is separate from and independent of the engine, and is supplied with air compressed to about 42 atmospheres, and all the air delivered to it is liquefied; whereas, the air supplied to the engine is compressed to not exceeding 180 pounds gage (often at not over 150 pounds). As stated, it is to be operated in a closed-circuit; that is, the same air is worked over and over—compressed, water-cooled, refrigerated in the pre-cooler and the counter-current thermal interchanger by the cold exhaust air from the engine, utilized after expansion to liquefy the high-pressure air in the liquefier coils first, and thence used to cool

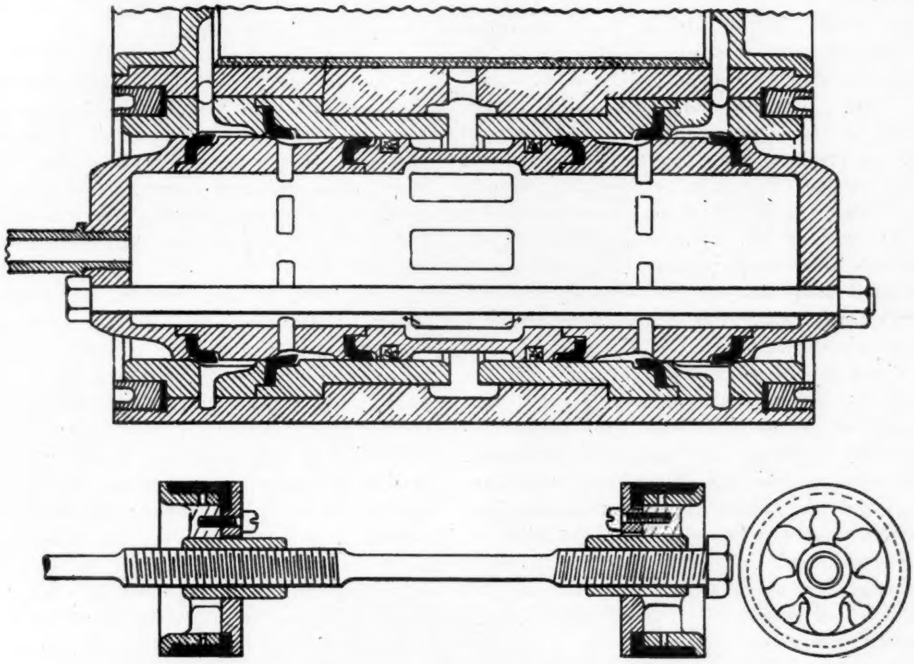


FIG. 4—THE PLACE BALANCED VARIABLE CUT-OFF AIR VALVE FOR WORK WITHOUT LUBRICATION.

both the compressed air supplied to the liquefying coils and that of less compression being supplied to the engine; and then (after cooling the engine compressed-air supply alone) returned to the compressor to go through the same cycle again.

There are many details, a description of which would make this article too long. It is sufficient to say that the engine runs smoothly in all its parts, easier when it is using air at an initial temperature of —200° or —220° than when the initial temperature is normal, as at starting up. As the compressed air in the liquefying coils liquefies at its critical temperature, —220° F., and while at or above its critical pressure, it is not necessary to run the engine so that the exhaust will be below —240° to —280°. The air used in the engine is absolutely devoid of either moisture, carbonic acid gas, or anything else. It is pure nitrogen and pure oxygen; therefore, as there was nothing to freeze, I experienced no trouble whatever from frost or ice. The quick lime, calcium chloride and caustic potash drums are so constructed inside that the air is brought in direct contact with successive charges of these hygroscopic substances.

Three things which have been a source of difficulty, heretofore, in liquefying air, I succeeded in putting behind me from the start—moisture, carbonic acid gas, and insulation. The arrangements for elimination of the first two, and the design for securing the last, worked most satisfactorily—the pre-cooler, interchanger and CO_2 cooling drums all being thoroughly insulated with a mat of from 3 to 8 inches of wool, and covered with shellac-treated canvas.

The indicator cards here reproduced are on a scale of 80 pounds to the inch, the side to the right being the crank end in each case. Of the indicator diagrams shown, Nos. 1 and 2 are friction cards—the engine running free, without load. No. 3 is a card with load, soon after starting up, the initial temperature being normal, and the engine not having become cooled much below zero, the exhaust temperature varying, showing about 40° below, but constantly falling as the cold exhaust air cools the incoming supply of compressed air. In starting up the engine I usually started with 80 pounds to 100 pounds gage pressure, and gradually increased the compression, as the engine got cooled, to 160 pounds to 180 pounds; sometimes running on 150 pounds, and getting quite as good results therefrom as when the higher compression was used.

No. 4 card is almost ideal. There is a very slight throttling of the release on the head end after the piston has passed the dead centre, and there is, as shown, a trifle more clearance on the crank end than on the head.

This unequal clearance is corrected in card No. 5, and reduced a trifle at both ends.

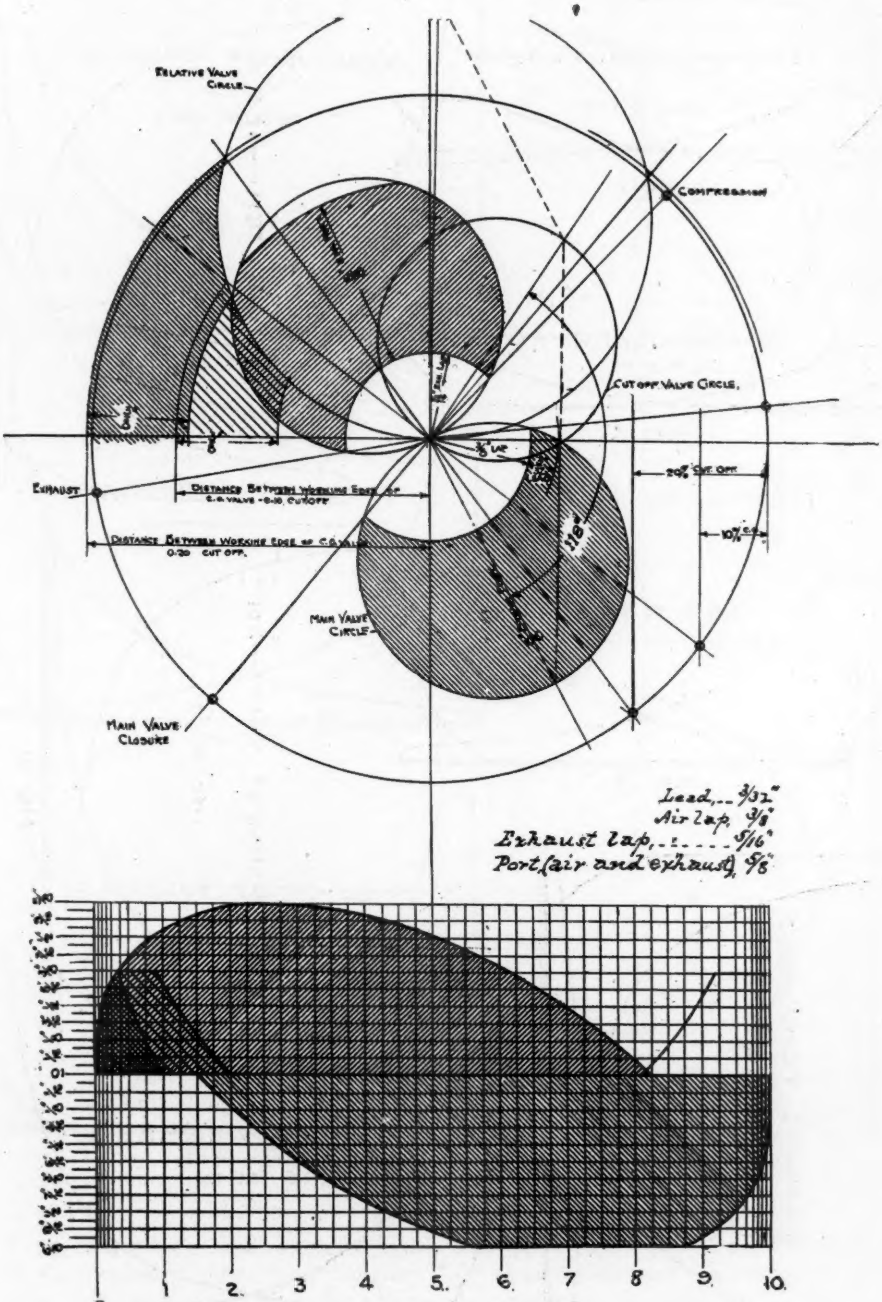
Cards Nos. 6 and 7 were taken a month apart, and some changes may have been made in the clearance and valve-setting; but the exhaust temperature was the same in each case, 200° below zero. Note the sharp cut-off in these cards.

In cards Nos. 8, 9 and 10 the expansion was not to atmosphere, their being about 10 pounds gage at release in Nos. 8 and 10. The back pressure in these, as well as in all of the cards, shows about 1½ pounds. These three cards were taken on three successive days, No. 10 being taken when running at considerably lower exhaust temperature than the others, or at —280° F.

Cards Nos. 11 and 12 were taken at still lower temperatures, or with the exhaust at 292° and 310° below zero, respectively. The initial cylinder pressure used when these cards were made was but 147½ pounds and 150 pounds gage, respectively.

Cards Nos. 8, 9, 10, 11 and 12 may all be regarded as vapor cards, as the air was exhausted in each at temperatures below the critical temperature of air. The temperature given on the cards was taken by a pentane thermometer in the exhaust conduit, just where it leaves the insulation surrounding the cylinder, about 16 inches from the valve; this exhaust conduit leads to the conduit enclosing the liquefier supply coils, and is of course heavily insulated with wool felt and fine washed wool.

I regard No. 12, when the engine was exhausting at a temperature of 310° below zero, as nearer a perfect expansion card than any of the others. The engine was then liquefying air in the cylinder, for the exhaust as it passes out over the ends of the valve is slightly raised in temperature. The compression (or cushioning of the piston) I purposely made as small as considered safe to run with, for compression neutralizes refrigeration. In this card (No. 12) there is just the least bit more compression on the crank than on the head end; otherwise the card is perfect. A trifle earlier



The Place Air-Valve.—Port-Opening Diagram.
10% and 20% Cut-off (6 5/8" × 10").

FIGURE 5.

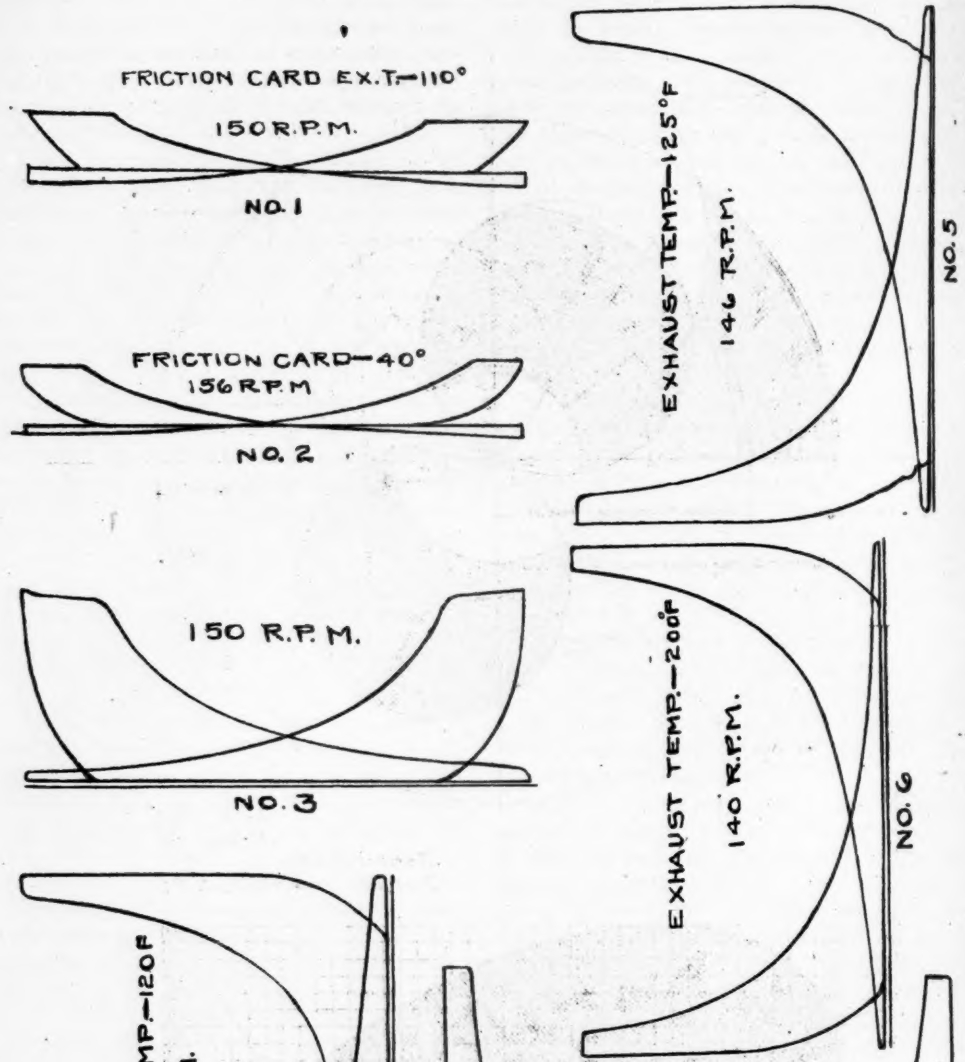

FRICTION CARD EX.T.—110°
150 R.P.M.
NO. 1
FRICTION CARD—40°
156 R.P.M
NO. 2
150 R.P.M.
NO. 3
EXHAUST TEMP.—120F
130 R.P.M.
NO. 4
EXHAUST TEMP.—125°F
146 R.P.M.
NO. 5
EXHAUST TEMP.—200°F
140 R.P.M.
NO. 6
EXHAUST TEMP.—200°F
148 R.P.M
NO. 7.

FIGURE 6.

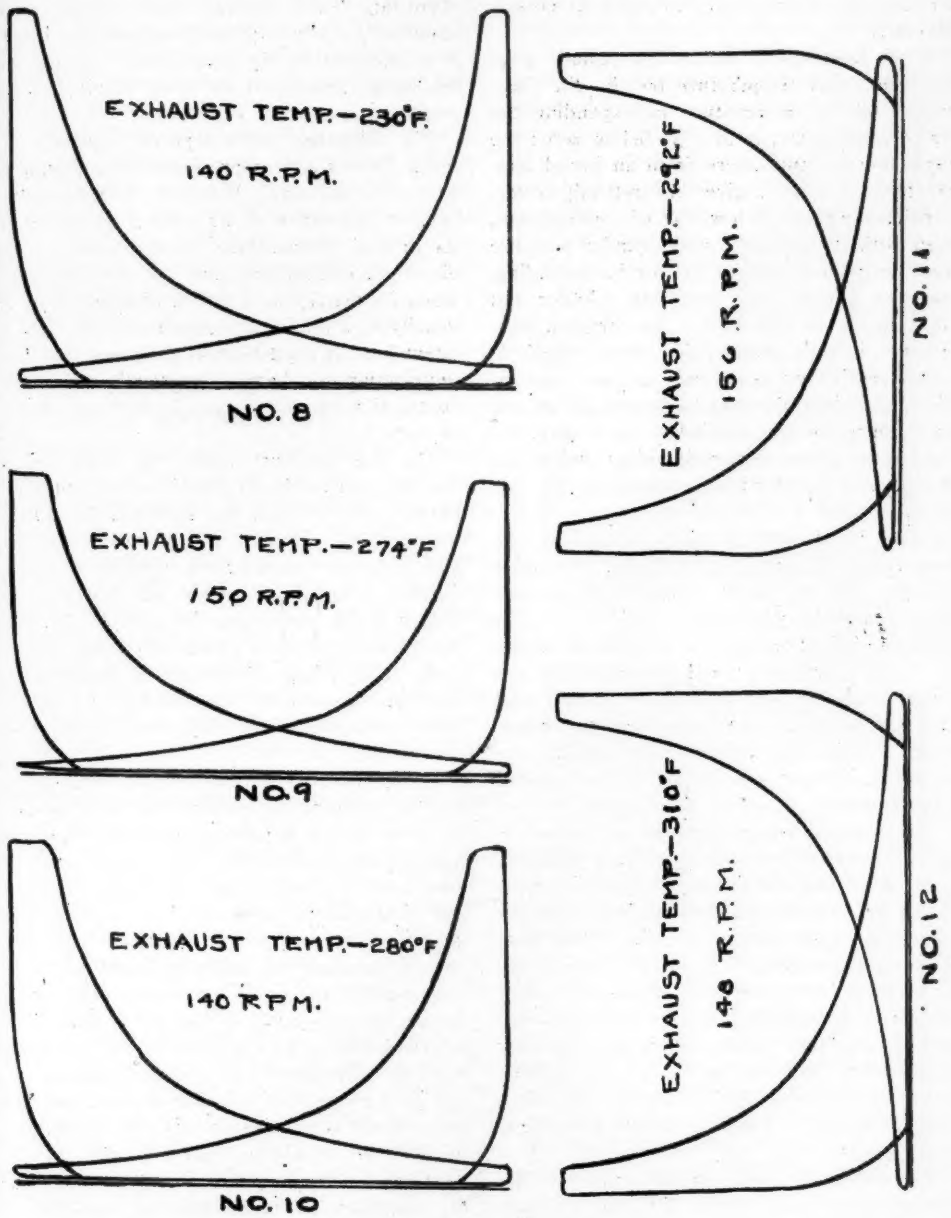


FIGURE 7.

cut-off could have been used, so as to have carried the expansion down to atmosphere. Analyzing this card (12) I find the actual cut-off was 5 per cent., the piston displacement being 344.7 cubic inches, and the clearance (including indicator pipes) was 26.5 cubic inches. Therefore, the initial volume expanded was $344.7'' \times .05 + 26.5'' = 43.7$ cubic inches, at 150 pounds gage; and the volume or space it was expanded into was $344.7'' + 26.5 = 371.2$ cubic inches; so that it was working with an actual expansion of about one volume into 8.5 volumes, or the equivalent of about 11.8 per cent. net cut-off; and yet it was expanding the

air from 150 pounds gage to about 21 pounds absolute.

With compressed air at 175 pounds gage and the initial temperature 60° F., the theoretical fall in temperature in expanding the air to atmosphere, is to 213° below zero; the expansion to atmosphere from an initial temperature of —180°, gives theoretically a terminal temperature below that of condensation, even with no greater initial cylinder pressure than 150 pounds gage. The air in expanding, however, absorbs heat from the cylinder and all its parts, so that at first the terminal temperature is very considerably above the theoretical result; but as the cold exhaust air continues to reduce the temperature of the incoming compressed air supplied to the engine, the exhaust air grows uniformly colder and colder until partial liquefaction is reached in the cylinder, (—312.6°).

I had no means of taking accurately the temperature of the compressed air in the valve chamber, or the initial cylinder temperature before expansion; but when card No. 12 was taken this initial temperature, I have no doubt, was —180° or lower; and the result of any lower initial cylinder temperature than —180° with 150 pounds gage expanding to atmosphere, would simply be increased cylinder condensation, without any change in the terminal temperature.

The ratio of density between air at 60° F. and air at —200°, the pressure being constant, is about 2; therefore in theory it takes 2 cubic feet of the compressed air delivered from the compressor water-cooler, to make 1 cubic foot of the same compressed air in the valve chamber, when the temperature there is —200°. The air as exhausted from the cylinder when card No. 12 was made, before passing over the liquefier coils, was in theory considerably less than one-third the volume of free air—notwithstanding it was at substantially atmospheric pressure.

The engine is made to do work on the counter-shaft which drives the high-pressure compressor; and as near as I can judge, we recover from it ordinarily about 22½ per cent of the power required to compress the air it uses (possibly not over 20 per cent.), varying with the initial temperature of the compressed air expanded in the engine. This initial temperature rises or falls according to the amount of liquid drawn from the liquefier, or the frequency with which it is drawn therefrom; or according to the amount of heat allowed to be absorbed by the expanded exhaust air before it is delivered to the interchanger to cool the incoming compressed air being supplied to the engine.

The advantage of a separate liquefier and using therein air compressed to 600 pounds is, that all of the air is liquefied (without reduction of pressure) at its critical point—or at its critical temperature (—220°) and at or above its critical pressure (39 atmospheres), when its density as a gas is identical with its density as a liquid; and, therefore, there is no latent heat of condensation given out to retard liquefaction, as there is practically no further contraction of volume involved in its change of state.

The high-pressure liquefying coils deliver the liquefied air by gravity to a high-pressure liquid receiver; and the liquefied air as released from pressure and drawn from this high-pressure receiver is delivered to a vacuum-jacketed container or low-pressure holder which surrounds the receiver; so that this liquid receiver is practically a sub-cooling tank, as it is kept submerged in liquid air of atmospheric pressure, the surplus or overflow liquid from the holder only being drawn from the system.

By this method of liquefying air when at its critical pressure, by utilizing the cold exhaust air from the air-expansion engine to cool such high-pressure air down to its critical temperature, and then delivering it as liquefied (without reduction of pressure) to a cooling tank or receiver submerged in liquid air of atmospheric pressure, the newly liquefied air in the submerged receiver is sub-cooled after liquefaction, from —220° to —313°, so that there is practically no loss by vaporization on being released from pressure; and the released liquid as it evaporates (or that portion which is evaporated after release in sub-cooling the liquefied air which has taken its place in the submerged high-pressure receiver) requires the maximum of latent heat of vaporization (or about 120 B t u per pound) to evaporate, all of which must be taken from the liquid air in the submerged receiver, or from the liquid itself as released. Besides, all vapors from the low-pressure liquid holder are utilized to cool the air to be liquefied, as all such are conducted back over the incoming supply of compressed air, being mixed in the out-flowing expanded air conduit with the exhaust air from

the engine. *The resultant product of liquid air drawn from the system is about 7½ pounds per h.p.h. of energy expended.* Greater economy may be expected as the machinery gets worn down to its work.

This article would be incomplete without due acknowledgment of the untiring efforts and constant work of Mr. John A. Inslee, President of the New England Refrigerating Co., during the past three years, in financing the company and otherwise aiding in bringing the enterprise to final success.

Glen Ridge, N. J., February 22, 1908.

A LIQUID AIR RESCUE APPARATUS

A device employing liquid air for rescue apparatus to be used in coal mines and elsewhere when the air is unbreathable has been invented by Mr. Otto Simanis, Norfolk House, Strand, London, and the London correspondent of the *Scientific American* has forwarded a description. The "Aerolith," as it is called, comprises a bag, containing the liquid air absorbing medium, which is strapped to the wearer's back like a knapsack. The apparatus weighs only 24 pounds when fully charged. From the top of the knapsack extends a flexible tube connecting an upper section of the chamber containing the absorbed liquid air with the mouth, there being a mask fitted over the entire face with mica glazed apertures for the eyes, or simply a mask inclosing the eyes and mouth. This flexible coupling is connected by another short length of flexible tube, the connection being made about 6 inches below the mouth to the liquid air container at the opposite upper section.

The most essential part of the apparatus is the compartment containing the liquid air. This is filled with asbestos wool, which the inventor has discovered to be the best of all absorbing substances, while at the same time it enables evaporation to be automatically controlled. This absorbent is thoroughly regulated by special means, so that not only is evaporation from external heat avoided when the apparatus is not in operation, but, when evaporation is in progress, to effect it so gradually as to be just sufficient for the needs of the wearer's lungs. Attached to the apparatus and lying flat against its outer surface is a second bag, through which escapes exhaled air from the lungs.

The wearer clamps the mask carrying the mouthpiece from the liquid air chamber to his mouth, and commences to breathe in a normal manner. The warm expired air from the lungs passes through the tube, and enters the chamber containing the absorbed charge of liquid air. This at once causes the evaporation of a small quantity of liquid air of the same volume as would be exhaled by a man under ordinary circumstances. This evaporated charge passes up the second tube, and by the next inhalation

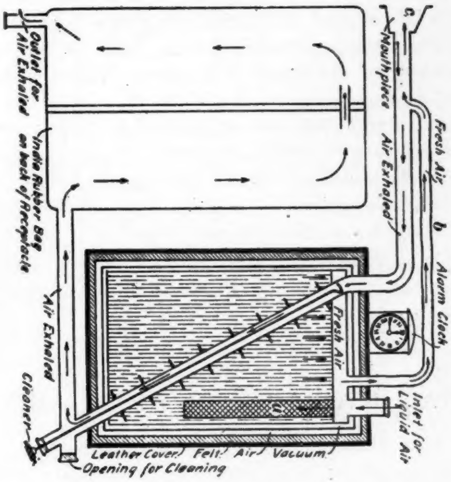


DIAGRAM OF AEROLITH APPARATUS.

is drawn into the wearer's lungs. This cycle of operations is repeated, the warm expired breath evaporating charges of fresh air until the supply has become exhausted. The atmosphere evaporated from the absorbing material is cool, fresh and pure, the intensely cold vaporized air being warmed by its passing through the tube, so that by the time it reaches the mouth it can be inhaled without the slightest discomfort. The expired air, after passing over the absorbing medium and releasing the requisite quantity of fresh air in its passage, finally escapes into the outer atmosphere.

The liquid-air absorbent reservoir is charged from a supply carried in a small receptacle, the liquid air being stored in a spherical vacuum vessel of the type evolved by Professor Dewar. This reservoir is well insulated, the loss from evaporation being very small. It is made of varying capacities according to requirements, the average capacity ranging from 0.7926 to 1.5852 gallons. As air in its liquefied state is compressed into one eight-hun-

dredth part of its normal volume, 1.32 gallons of liquid air evaporate into about 244,080 cubic inches of pure air at atmospheric pressure; this quantity is sufficient for about three hours' use.

In connection with the evolution of the "Aerolith" apparatus, the inventor has also devised a cheaper method of producing liquefied air. With the apparatus he has designed the cost of production is approximately 18 cents per gallon, but by the aid of some recent modifications it is anticipated that the cost will be reduced to 5 cents per gallon. In the case of large coal-mining areas, such as those existing in the north of England, Westphalia and Pennsylvania, it would be more economical to erect one central generating station to serve a large number of mines. A plant with an 8 horse-power engine and capable of producing one gallon of liquid air per hour, can be erected for about $2,000.

[It will be noted that the preceding article promises to produce liquid air more cheaply than this.]

COAL STORAGE OF HEAT AND ENERGY

A pound of coal represents five times as much energy as a pound of the strongest explosive known, blasting gelatine. My friend had overlooked the fact that a pound of dynamite, though it gives out nearly 150,000,000 H. P., does so only for the space of 1-50,000 of a second. He had omitted to take into account the element of time, and had confused power in the ordinary sense with energy, which is the capacity for doing work.

A similar confusion is sometimes made between energy and the creation of high temperatures. This can be very well illustrated by the use recently made of a finely-powdered aluminum, both as a component of explosives and as an agent for producing very high temperatures, in the shape of Dr. Goldschmidt's "thermit." In both cases the fact is utilized that aluminum is easily, and in the shape of fine powder, almost instantaneously, converted into its oxide, alumina, by substances capable of giving off oxygen. In the case of thermit, a mixture of finely-powdered aluminum and ferric oxide is, when lighted, decomposed instantaneously into molten iron and aluminum oxide. The heat produced thereby far exceeds that produced by coal in any conceivable way; it is equal to that of the electric arc. One of the most important applications of this agent occurs in the welding of the ends of railway rails, when already laid down, into one continuous rail of any length required. And yet the total energy of thermit is only 450 thermal units per kilogram, or in other words, about one-twentieth of that of the best coal. But, whereas, it takes a good deal of time to burn a pound of coal, during which process there is a great loss of heat by radiation, and the heat is spread over a current of gases which we call the flame, a pound of thermit burns off in about one second, and, as there are no gaseous products formed, all the heat generated remains within the molten iron and alumina, which accounts for the extreme degree of heat to which these are brought.—*Prof. George Lunge, Royal Institution.*

AIR LIFT AGITATION IN CYANIDING

That fine grinding of most of the ores to be treated by the Cyanide Process is beneficial is generally admitted. The quartzose envelope of the metallic particles has to be broken in order to allow contact with the dissolving medium and so, departing from former practice, it has more and more become the endeavor of metallurgists to "slime" all the ore and, abandoning the separation of the real slimes from the fine sands, agitating both together. Mechanical stirrers assisted by centrifugal pumps were used with some success, but it was found that the presence of even fine sands made the operation uncertain, and costly.

An improved method of agitating mixtures of slimes and sands has been invented by Mr. F. C. Brown, manager of the Komata Reef Gold Mines in New Zealand and introduced by him on several important works in that country with remarkable success. Compressed air is used for this purpose, applied in a peculiar manner in tanks of which the accompanying cut is a sectional elevation. The tanks are cylindrical in appearance but consist internally of a cylindrical part terminating in a cone with a 60 degree slope. The weight of the tanks and contents is transmitted by the continuation of the cylindrical shell, stiffened by vertical angle bars, to a double angle iron resting upon a solid foundation. The lower

end of the cone is closed by a cast iron bottom. A doorway in the lower part of the shell gives access to the space around the cone and a manhole in the latter facilitates inspection of the valves, etc., when the tank is empty. The discharge of the contents, after agitation, takes place through a pipe near the bottom, provided with a valve, cock or plug.

The internal fittings of the tank consist of:

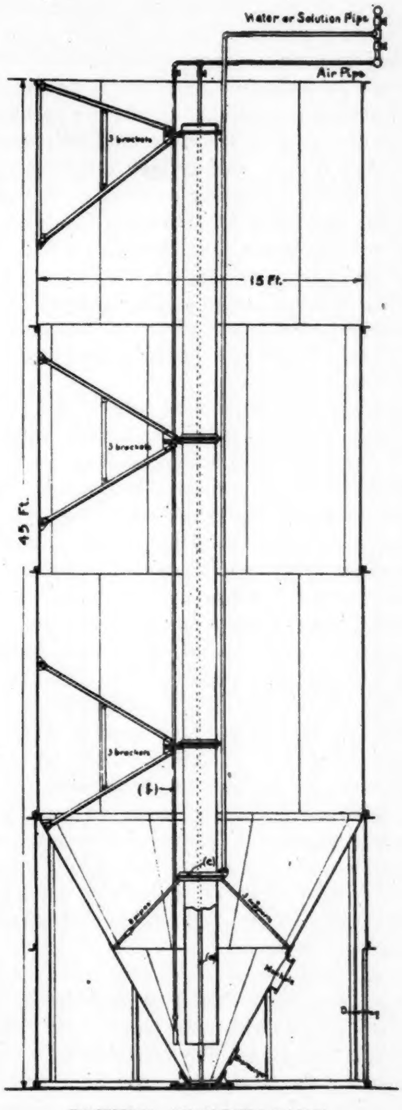
1. A central tube called the air lift, of a diameter of about one-twelfth of that of the tank. It is open at both ends and extends from about 18 inches above the charging level to the same distance from the lowest point of the cone. It is supported by means of brackets as shown in the drawing, there being three of them in each set.

2. An air pipe (a) in the center of the lift, closed below and resting on the bottom of the tank, has at the level of the inlet of the air lift a "sleeve" valve which prevents the pulp entering and allows the air to escape in an upward direction when the air-pressure exceeds that due to the head of pulp in the tank.

3. A second air pipe (b) outside the lift which serves to keep the pulp in gentle motion while filling or emptying the tank when the submergence is insufficient to allow the air lift to work.

4. An apparatus consisting of an annular casting (c) surrounding the air lift, supported on the sides of the cone and provided with a number of pipes having sleeve valves discharging against the cone, the apparatus being connected to the air, and water or solution pipes. This arrangement is sometimes useful when discharging to wash down the sands which may have settled on the cone after the agitation is stopped.

The mode of operation, like the apparatus, is very simple. The tank being filled with ground ore and solution, air is admitted through pipe (a), which, mixing with the contents of the lift, lightens the column inside and causes it to overflow, while fresh pulp runs in at the bottom and is in turn brought to the top, thus producing a perfect circulation which is kept up as long as the supply of air lasts. The initial air pressure has to exceed that of the column in the air lift, but when once circulation has been established the pressure can be considerably reduced. At first also a greater quantity of air is required in order to obtain a sufficient velocity of circulation to remove all the pulp which may have packed on the cone during the period of filling. To commence operations 50 pounds of air pressure are used, but when the cone is clear of sand, the half of this pressure is sufficient. The quantity of free air consumed depends upon the propor-



PACHUCA AGITATING TANK.

tion of slimes and sands, the degree of grinding and the viscosity of the pulp. In most cases 100 cubic feet of free air per minute will keep the mass in lively motion and prevent the settling of sands on the cone. Large tanks loaded with slimes only are agitated in N. Z.

with an expenditure of less than one horse-power. For a plant treating 100 tons per day of mixed sands and slimes a 10-horse-power compressor is sufficient.

The agitation by these means is perfect, and very efficient aeration of the mass is obtained at the same time. Even after weeks of rest, when the contents of the tank have packed to a hard mass in the cone, agitation can be readily started and after about one hour the mass is in perfect circulation. Sands can be treated as readily as slimes and as they fall through the solution more rapidly than the slimes they receive a more energetic treatment. It is clear that the dissolving action of the cyanide solution is much more rapid than when less perfect modes of agitation and aeration are used. In fact, 24 hours' treatment are generally sufficient, and extractions of 92 per cent. of the silver and nearly all the gold have been obtained in that time.

The first cost of a plant of this description is much less then when mechanical agitation of the ordinary kind is used and the treatment charges are also considerably reduced. One man can do all the work connected with the agitation of a 100-ton plant. There is no danger of anything getting out of order and no chance of the contents settling down.

The above description we take from the *Mexican Mining Journal,* which says further: The system was introduced into this country by Mr. A. Grothe in the Hacienda de San Francisco at Pachuca and results there obtained induced the San Rafael and La Union Companies at Pachuca to put in 200 and 100-ton plants respectively. A 50-ton installation is under way at the Natividad Company's mill in Oaxaca, while the Veta Colorado Mining & Smelting Co., of Parral, is building an experimental plant of two tanks of 15 feet diameter and 45 feet high.

A power contract has been made by the city of New York with the New York Edison Company for current for operating the electric pumps for the new emergency high pressure fire mains. *A penalty of* $500 *per minute* is imposed for delay of the electric power supply beyond three minutes after a fire alarm.

The wettest place on earth is reputed to be Cherrapunji, India, and a recent fall of 74½ inches of rain in five consecutive days must discourage other competitors for the record.

EFFICIENCY TESTS OF AIR LIFTS AT SOUTH AFRICAN MINES

The two 200-stamp mills erected about a year ago by the East Rand Proprietary Mines, Limited, on the properties of the Cason and Angelo Companies have several features of interest, not the least important of which are the air lifts used for raising the sands and slimes pulps to the settling tanks. The air lifts in the above plants replace the ordinary tailings wheel, or the less frequently used tailings pump, and, as these are the only two plants on any of the Witwatersrand mines in which an installation of air lifts is entirely relied upon for lifting pulp, their operation has

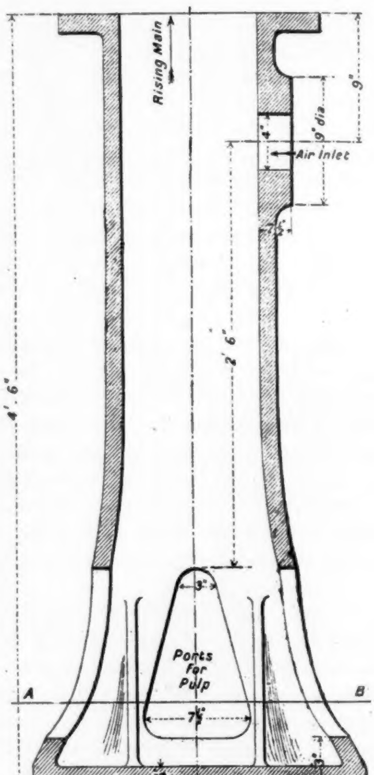


FIG. I.—FIRST FOOT PIECE.

been watched with a considerable amount of interest by local engineers.

An air lift pump consists of (1) a foot piece provided with ports for the admission of the liquid to be lifted and a compressed air inlet, and (2) a rising main. The foot piece is sunk

to a distance below the level of the liquid to be raised proportionate to the head to be lifted against, and compressed air is admitted at the air inlet, the initial air pressure necessary being dependent upon the pressure in the well or sump at the point of air admission to the foot piece.

The operation of the "lift" is dependent upon the aeration of the column of liquid contained in the rising main, and not upon an ejector action, as is erroneously imagined by many engineers. The maximum efficiency of a given "lift" is therefore attained when the head to be lifted against, the proportion of submersion to head, and the pressure of the compressed air at the air inlet are in correct ratios. If the air pressure is too high the amount of work performed in attaining the excess pressure is lost. If the degree of submersion is too great in proportion to the head, then it is necessary to raise the air pressure higher than is economical in order to deliver it into the foot piece against the increased liquid pressure due to the excess

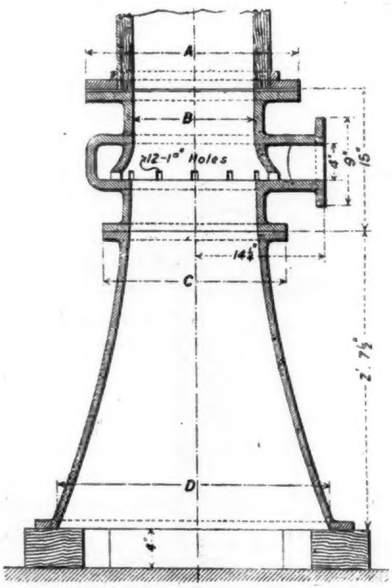


FIG. 2—IMPROVED FOOT PIECE.

submersion, with a resultant loss of efficiency. On the other hand, if the proportion of submersion to lift is not great enough there is not sufficient aeration of the column of liquid to give the requisite velocity to the column without the use of an unduly large volume of compressed air—as expressed in its equivalent amount of free air—per cubic foot of liquid lifted, this again resulting in a loss of efficiency if the power requisite to compress the larger volume of free air to the lower pressure required is greater than that necessary to compress the smaller quantity to a higher pressure.

In the absence of trustworthy data upon which to base calculations for the Angelo and Cason plants, it was essential that a series of

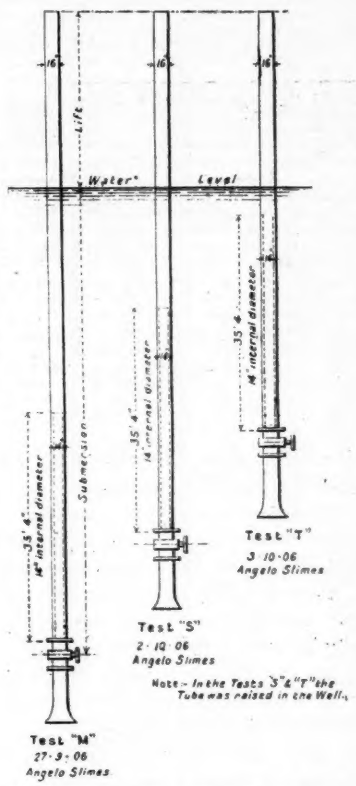


FIG. 3.—POSITION OF TUBES IN WELL.

tests should be carried out to ascertain the most economical ratios of the three determining factors. These tests, the results of which are tabulated below, were carried out by Mr. R. Henderson, the construction engineer of the East Rand Proprietary Mines, Limited, under the direction of the company's consulting engineer, Mr. N. Wilson.

The "lifts" are, in both the Angelo and Cason plants, arranged in groups for sands and slimes, respectively. Each tube is placed in a separate well or sump, which for a few feet at the top is extended in area so that variation in the quantity of liquid flowing to the well

may not cause too rapid fluctuations in the level. By this arrangement the tube can be fixed in a well very little larger than its own diameter, and yet the level of the liquid can be kept practically constant. A float which, as it rises and falls with the level of the liquid, rotates a small plug valve regulates the supply of compressed air to the tube, and provides for irregularities in the flow to the well. The design of the foot piece originally experimented with is shown in Fig. 1. Four ports at the lower end, which is belled out, provide for the

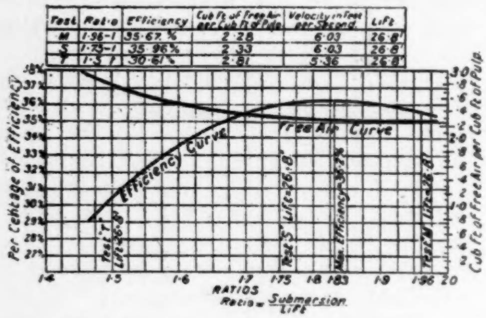


FIG. 4.—EFFECT OF VARYING RATIOS.

admission of the pulp, whilst through a 4-inch hole, placed 2 feet 6 inches above the top of the ports, compressed air is admitted. This design was found to be very inefficient, and later tubes were fitted with the type shown in Fig. 2, which is belled out at the lower end to a greater extent than in the original type—so as gradually to accelerate the velocity of the liquid—and the bottom is open, the foot piece resting on four timber supports. An air belt is provided 3 feet 3 inches above the bottom of the foot piece, this belt delivering air to the tube through a ring of twelve holes, each 1 inch square. This design gave vastly improved results. The dimensions at A, B, C and D for the foot pieces of the various tubes were:

Dimensions of foot piece. A	B	C	D	Where used.	Tests.
in.	in.	in.	in.		
21	11½	19	22	Angelo Slimes and Cason Sands	E.I.J.K.L. / No. 1.
23	13½	20	30	Angelo Slimes and Cason Slimes	D.M.S.T.N.O.P.Q.R. / No. 2.

The rising main used was mild steel tubing, expanded into cast steel flanges. The lengths of main were made uniform so as to be interchangeable. The mains used with the foot pieces having 11½ inches diameter throats were 14 inches internal diameter, whilst those with foot pieces having 13½ inches diameter throats were 16 inches internal diameter. The lower portions of the rising mains were in each instance reduced 2 inches in diameter by a lining of timber 1 inch thick. This lining serves a double purpose, as it protects the lower lengths of main from damage by abrasion—the sands to a greater and the slimes to a lesser degree exercise a cutting action in their flow—and also, by restricting the area in the lower length tends somewhat to equalize the velocity of flow in the length of the main. The air bubbles, by expanding as they rise and decrease in pressure, increase the velocity of flow of the aerated liquid as it rises, if the main is of uniform diameter throughout. A main of gradually increasing (or tapered) diameter would be necessary to provide an absolutely uniform velocity throughout its vertical length, and this would, of course, be commercially impossible to provide. The general arrangement of the "lift" and well is shown in Fig. 5.

In carrying out the experiments at the Angelo Slimes plant, a series of seventeen tests were made, as shown in Tables I. to V., the

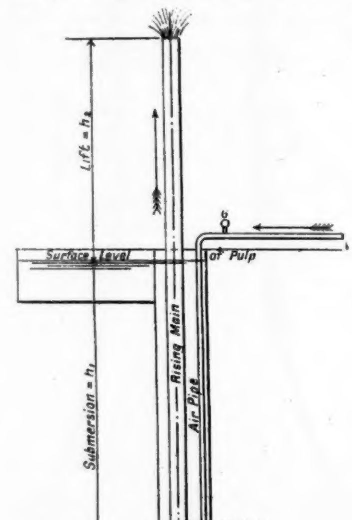


FIG. 5.—GENERAL ARRANGEMENT OF AIR LIFT.

following being the method employed in obtaining the various data.

Air measurement.—A special air compressor was used for the purpose of working the air lifts. The compressor was run at such a speed as to keep the level of the slimes in the well

of the "lift" constant. The revolutions of the compressor were then noted and kept constant during the test. Then, knowing the revolutions and the piston displacement of the air compressor, the consumption of free air per revolution or per minute could be obtained.

Slimes.—"Slimes" means a mixture of water and the very fine or "slimy" portion of the crushed ore coming from the reduction plant.

Slimes measurement.—When everything was running steadily, the slimes to be dealt with was measured in a 50 feet diameter tank; the flow in cubic feet per minute thus being obtained.

Specific gravity of slimes.—A number of samples of the slimes were taken and the specific gravity obtained, an average of the results being taken.

Theoretical H. P. in lifting slimes a height $=h_2$.—The specific gravity used for determining the theoretical H. P. was taken as 1.1013, or 63.3 pounds per cubic foot of slimes.

Adiabatic compression $P_1 V_1^{1.408} = P_2 V_2^{1.408}$

$$\text{M.E.P.} = 3{\cdot}45 \left\{ P_2 \left(\frac{P_1}{P_2}\right)^{\cdot 71} - P_1 \right\}$$

i = H.P. per cubic foot of free air

$$= {\cdot}015042 \left\{ P_2 \left(\frac{P_1}{P_2}\right)^{\cdot 71} - P_1 \right\}$$

$$\text{Efficiency per cent.} = \frac{\text{Theoretical H.P.}}{\text{Air H.P.}} \times 100$$

Index of Symbols used in Calculations:—

h_1 = Depth of submersion in feet.
h_2 = Height of lift in feet.
V = Velocity in feet per second of the pulp through the throat.
Q = Quantity of pulp in cubic feet per minute.
C = Constant for theoretical H.P. $= \frac{63{\cdot}3}{33{,}000} = {\cdot}001918$.
G = Gage showing working pressure of air (see Fig. 5).
i = H.P. per cubic foot of free air compressed t P_2.
M.E.P. = Mean of effective pressure.
P_1 = Atmospheric pressure (absolute) = 12·5 lb. per square inch.
P_2 = Working pressure at the air lift (absolute).
A = Cubic feet of free air per minute.
a = Area of throat of the foot piece of rising main in square feet.
P = Working pressure at the air lift (gage).

	Test.	B.	C.	D.	E.
Conditions.	Date	11-7-06	11-7-06	16-7-06	16-8-06
	Tube	East and West	East and West	East	West
	Number and size of tubes used	Two 10in.	Two 10in.	One 14 to 16in.	One 12 to 14in.
	Submersion, in feet	32 75	35·75	37·75	48·85
	Lift, in feet	32·5	29·5	27·5	27·09
	Ratio submersion to lift	1·009 to 1	1·21 to 1	1·372 to 1	1·77 to 1
	Working gauge pressure, in lb. per square inch	15	16	17	22
	Average number of stamps running	155	157·5	145	160
	Kind of foot piece	Fig. 1	Fig. 1	Large, Fig. 2	Small, Fig. 2
	Throat diameter of foot piece	10in.	10in.	13¼in.	11½in.
Performance.	Free air per minute, in cubic feet	2256	1279	796·48	846
	Free air per minute per stamp, in cubic feet	14·5	8·12	5·49	5·28
	Free air per cubic foot of slimes, in cubic feet	7·27	4·06	2·74	2·64
	Cubic feet of slimes per minute	310	315	290	320
	Cubic feet of slimes per stamp per minute	2·0	2·0	2·0	2·0
	Throat velocity, in cubic feet per second	4·7	4·8	4·855	7·39
	Theoretical horse-power	19·3	17·8	15·23	16·6
	Horse-power per cubic foot of free air compressed	·048	·050	·053	·064
	Air horse-power	108·72	64·74	42·21	54·144
	Efficiency, per cent.	17·7	27·5	36·15	30·55

TABLE I.—AIR LIFT AT ANGELO SLIMES PLANT.

Theoretical H. P.

$$= \frac{\text{Quantity of pulp in cub. ft. per min.} \times 63{\cdot}3 \times \text{lift in ft.}}{33{,}000}$$

$$= \frac{Q \times 63{\cdot}3 \times h_2}{33{,}000}$$

$$= C \times Q \times h_2$$

$$= {\cdot}001918 \times Q \times h_2.$$

Air H. P.—This was obtained by multiplying the cubic feet of free air per minute by the value of the H. P. required to compress one cubic foot of free air to the working air pressure, as shown in this case on the gage G, Fig. 5. In these tests it has been assumed that the compression is adiabatic, and therefore taken under worst conditions.

REMARKS ON TESTS.

Table I. *Tests B, C, D and E.*—It will be noticed that these tests, taken in the above order, have increasing depths of submersion and decreasing heights of lift, the ratio $\frac{\text{Submersion}}{\text{Lift}}$ varying from 1.009 to 1 to 1.77 to 1. *Tests B and C* were each run with two 10-inch tubes.

The cubic feet of free air used to one of slimes being 7.27 and 4.06 cubic feet respectively, the latter being with the greater depth of submersion. The efficiency was 17.7 per cent. and 27.5 per cent. respectively. The original type of foot piece was used. See Fig. 1.

In Test D a 14-inch widening to 16-inch diameter tube was used.

The ratio $\frac{\text{Submersion}}{\text{Lift}}$ was increased to 1·372 to 1.

The ratio of cubic feet of free air to cubic feet of slimes lifted in this case was reduced to 2·74 to 1, the efficiency being increased to 36·15 per cent.

The new type of foot piece was used in this test, with a throat diameter of 13½ inches. See Fig. 2.

Test E.—A 12-inch widening to 14-inch diameter tube was used.

The ratio $\frac{\text{Submersion}}{\text{Lift}}$ being increased 1·77 to 1. The consumption of free air per cubic foot of slimes lifted was further reduced to 2·64 to 1.

It will be noticed that in this test the submersion was considerably greater than in Tests B, C and D. This increased submersion necessitated the increase of the working air pressure from 15 pounds to 22 pounds. Pressure being an important factor in obtaining the air horse-power accounts for the decrease in the efficiency to 30.55 per cent. as compared with Test D. The foot piece used in this case was the same type as in Test D, but with 11½ inches throat diameter.

Summary, Table I.—These tests can, under the circumstances, hardly be taken as comparative, but more as progressive, for in each test the conditions were altered.

The ratio $\frac{\text{Submersion}}{\text{Lift}}$ suggests that there is a point where, under certain conditions, a maximum efficiency can be obtained. However, later tests show this more clearly. Another detail shown to be of importance is the throat velocity.

Table II. Tests I and M.—These two tests were carried out on the same day. Test I: a 12 inch widening to a 14 inch diameter tube, and in Test M a 14 inch widening to a 16 inch diameter tube being used. The ratio of submersion to lift being 1.8 to 1 and 1.96 to 1 respectively. Test M shows a decreased consumption of air per cubic foot of slimes and an increased efficiency as compared with Test I, the better performance being obtained with the smaller throat velocity. The increased efficiency is very small, but would no doubt have been greater with a ratio of submersion somewhere about the same as Test I.

Table III. Tests M, S and T.—In these tests it will be noticed that the ratio of submersion to lift is varied from 1.96 to 1 to 1.5 to 1; the lift being kept constant. In tests S and T the tube was raised in the well to alter the submersion—see Fig. 3, which illustrates this. The size of the tube used in each test was the same, viz., one 14 inches widening to 16 inches diameter with the same size, and the new type of foot piece with 13½ diameter throat. The curves shown in Fig. 4 show the effect of vary-

	Test.	I.	M.
Conditions.	Date	27-9-06	27-9-06
	Tube	West	East
	Number and size of tubes used	One 12 to 14in.	One 14 to 16in.
	Submersion, in feet	48·24	52·528
	Lift, in feet.	26·8	26·8
	Ratio submersion to lift ...	1·8 to 1	1·96 to 1
	Working gauge pressure, in lb. per sq. in.	21·5	24·0
	Average number of stamps running	180	180
	Kind of foot piece...	Small, Fig. 2	Large, Fig. 2
	Throat diameter of foot piece	11½in.	13½in.
Performance.	Free air per min., in cub. ft.	893	822·5
	Free air per min. per stamp, in cub. ft.	4·96	4·56
	Free air per cub. ft. of slimes, in cub. ft.	2·48	2·28
	Cub. ft. of slimes per min. ...	360	360
	Cub. ft. of slimes per stamp per min.	2	2
	Throat velocity, in cub. ft. per second...	8·34	6·03
	Theoretical horse-power ...	18·49	18·49
	Horse-power per cub. ft. of free air compressed... ...	·063	·068
	Air horse-power	56·26	55·93
	Efficiency, per cent.	32·7	33·1

TABLE II.—AIR LIFT TESTS AT ANGELO SLIMES PLANT.

ing the ratio of submersion to lift. Values being plotted for given free air consumption per cubic foot of pulp, and also for efficiencies at different ratios, the efficiency and consumption of air as ordinates and ratios of submersion to lift as abscissæ. It will be noticed that the point of maximum efficiency under the conditions of test is where the ratio = 1·83 to 1, giving an efficiency of 36.2 per cent. It will also be seen that the free air consumption curve becomes almost flat after this ratio is increased. The ratio of air to pulp not decreasing after this point, and the submersion increasing, the working air pressure, and, of course, the air horse-power per cubic foot of free air, is increased, this decreasing the efficiency.

Table IV. Tests M, N, O, P, Q and R.—This series of tests was carried out on the same day. The same sizes of tube, foot piece

and throat diameter were used, the same number of stamps were running—therefore the cubic feet of pulp to be lifted or dealt with per minute was constant—and the same throat velocity was attained, the varying conditions being the submersion and lift. The ratio submersion to lift varied from 1·96 to 1 to 1·01 to 1. The consumption of air to slimes varied from 2.28 to 7.83 cubic feet of free air per cubic foot of pulp, and the efficiency from 33.1 per cent. to 17.5 per cent. The tests seem to show pretty clearly that the most economical ratio is somewhere in the vicinity of 1·96 to 1 under these conditions.

Table V. Tests I, J, K and L.—The conditions of this test are very similar to those in Table IV. The ratio of submersion to lift varying from 1·8 to 1 to 1·41 to 1. The size of tube was different, the tube used being a 12 inches widening to 14 inches diameter. The foot piece was the same size new type. The difference of throat area raised the velocity to 8.3 feet per second compared with 6.03 feet per second in tests of Table IV. The average efficiency obtained was less than the average efficiency between the same limits of ratio submersion to lift in Table IV., thus suggesting that the throat velocity in the tests of Table V.

TABLE III.—*Air Lift Tests at Angelo Slimes Plant.*

	Test.	M.	S.	T.
Conditions.	Date	27-9-06	2-10-06	3-10-06
	Tube	East	East	East
	Number and size of tubes used	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.
	Submersion, in feet	52·528	46·9	40·2
	Lift, in feet	26·8	26·8	26·8
	Ratio submersion to lift	1·96 to 1	1·75 to 1	1·5 to 1
	Working gauge pressure, in lb. per square inch	24	21·5	18·75
	Average number of stamps running	180	187	175
	Kind of foot piece	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2
	Throat diameter of foot piece	13½in.	13½in.	13½in.
Performance.	Free air per minute in cubic feet	822·5	841·3	899·3
	Free air per minute per stamp in cubic feet	4·56	4·50	5·13
	Free air per cubic foot of slimes, in cubic feet	2·28	2·33	2·81
	Cubic feet of slimes per minute	360	360	320
	Cubic feet of slimes per stamp per minute	2·0	1·92	1·82
	Throat velocity, in cubic feet per second	6·03	6·03	5·36
	Theoretical horse-power	18·49	18·49	16·44
	Horse-power per cubic foot of free air compressed	·068	·063	057
	Air horse-power	55·93	53·002	51·26
	Efficiency, per cent.	33·1	34·8	32·0

TABLE III.—AIR LIFT TESTS AT ANGELO SLIMES PLANT.

	Test.	M.	N.	O.	P.	Q.	R.
Conditions.	Date	27-9-06	27-9-06	27-9-06	27-9-06	27-9-06	27-9-06
	Tube	East	East	East	East	East	East
	Number and size of tubes used	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.	One 14 to 16in.
	Submersion, in feet	52·528	46·292	45·696	43·978	39·895	39·895
	Lift, in feet	26·8	32·6	33·6	35·9	39·5	39·5
	Ratio submersion to lift	1·96 to 1	1·42 to 1	36 to 1	1·22 to 1	1·01 to 1	1·01 to 1
	Working gauge pressure, in lb. per square inch	24	22	21·5	20	19	18
	Average number of stamps running	180	180	180	180	180	180
	Kind of foot piece	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2	Large, Fig. 2
	Throat diameter of foot piece	13½in.	13½in.	13½in.	13½in.	13½in.	13½in.
Performance.	Free air per minute, in cubic feet	822·5	1175	1410	1880	2350	2820
	Free air per minute per stamp, in cubic feet	4·56	6·52	7·83	10·44	13·05	15·66
	Free air per cubic foot of slimes, in cubic feet	2·28	3·26	3·91	5·22	6·53	7·83
	Cubic feet of slimes per minute	360	360	360	360	360	360
	Cubic feet of slimes per stamp per minute	2	2	2	2	2	2
	Throat velocity, in cubic feet per second	6·03	6·03	6·03	6·03	6·03	6·03
	Theoretical horse-power	18·49	22·49	23·18	24·77	27·25	27·25
	Horse-power per cubic foot of free air compressed	·068	·064	·063	·060	·058	·055
	Air horse-power	55·93	75·2	88·83	112·8	136·3	155·66
	Efficiency, per cent.	33·1	29·8	26·1	22·0	20·0	17·5

TABLE IV.—AIR LIFT TESTS AT ANGELO SLIMES PLANT.

were too high. The same suggestion arises on comparing tests D and E, Table I., where the velocities are 4.855 and 7.39 feet per second and the efficiencies 36.15 per cent. and 30.55 per cent. respectively.

and were designed for much greater duties; the revolutions were therefore very low, and better results would have been obtained with small compressors driven by belts from the battery line shafts.

	Test.	I.	J.	K.	L.
Conditions.	Date	27-9-06	27-9-06	27-9-06	27-9-06
	Tube	West	West	West	West
	Number and size of tubes used	One 12 to 14in.	One 12 to 14in.	One 12 to 14in.	One 12 to 14in.
	Submersion, in feet	48·24	45·44	44·51	43·85
	Lift, in feet	26·8	29·7	30·7	31·1
	Ratio submersion to lift	1·8 to 1	1·53 to 1	1·45 to 1	1·41 to 1
	Working gauge pressure, in lb. per square inch	21·5	20·7	20·5	20
	Average number of stamps running	180	180	180	180
	Kind of foot piece	Small, Fig. 2	Small, Fig. 2	Small, Fig. 2	Small, Fig. 2
	Throat diameter of foot piece	11½in.	11½in.	11½in.	11½in.
Performance.	Free air per minute, in cubic feet	893	1222	1410	1880
	Free air per minute per stamp, in cubic feet	4·96	6·78	7·83	10·44
	Free air per cubic foot of slimes, in cubic feet	2·48	3·39	3·91	5·22
	Cubic feet of slimes per minute	360	360	360	360
	Cubic feet of slimes per stamp per minute	2·0	2·0	2·0	2·0
	Throat velocity, in cubic feet per second	8·34	8·31	8·31	8·31
	Theoretical horse-power	18·49	20·49	21·18	21·45
	Horse-power per cubic foot of free air compressed	·063	·0612	·061	·06
	Air horse-power	56·26	74·78	86·01	112·8
	Efficiency, per cent.	32·7	27·35	24·65	19·0

TABLE V.—AIR LIFT TESTS AT ANGELO SLIMES PLANT.

Two tests, shown in Table VI., were carried out on the Cason property, one each with one of the sands and one of the slimes tubes. The same methods were employed as in the Angelo tests, with the exception that the measurements of the pulp were determined by diverting the flow into the well of an idle "lift" which had been previously calibrated. The following additional details were determined.

Specific gravities.—The specific gravity of the slimes was taken as in the Angelo tests; that of the sands was found to be 1.033, or 64.56 pounds per cubic foot. The theoretical horse-power was calculated on this basis. Theoretical horse-power for sands lifted:—

$$\text{Theo. H. P.} = \frac{\text{Quantity of sands by } 64{\cdot}56 \times \text{lift in feet}}{33{,}000}$$
$$= C_1 \times Q \times h_2 = \frac{64{\cdot}56}{33{,}000} \times Q \times h_2$$
$$= {\cdot}001956 \times Q \times h_2.$$

"Sands" means the mixture of crushed ore and water coming from the reduction plant, from which, however, the "slimes" have been removed.

It will be seen from the tests that, under the best conditions, an efficiency of close upon 40 per cent. of the indicated horse-power in the steam cylinders of the air compressor was returned as work performed in lifting the pulp. The tests were handicapped by the fact that the air compressors used were far too large,

There is ample proof in the tests as tabulated that the air lift is, if carefully designed

	Test.	1.	2.
Conditions.	Where at	Sands Plant	Slimes Plant
	Date	21-7-07	26-7-07
	Tube	North	East
	Number and size of tubes	One 12 to 14in.	One 14 to 16in.
	Submersion, in feet	78·17	37·54
	Lift, in feet	43·0	17·33
	Ratio submersion to lift	1·817 to 1	2·166 to 1
	Working gauge pressure, in lb. per sq. in.	34·5	11·785
	Average number of stamps running	215	210
	Number of tube mills running	2	2
	Kind of foot piece	Small, Fig. 2	Large, Fig. 2
	Throat diameter of foot piece	11½in.	13½in.
Performance.	Free air per min., in cub. ft.	892·5	854·57
	Free air per min. per stamp, in cub. ft.	4·155	4·07
	Free air per cub. ft. of pulp, in cub. ft.	2·418	1·871
	Cub. ft. of pulp per min.	369	456·7
	Cub. ft. of pulp per stamp per min.	1·71	2·17
	Throat velocity, in cub. ft. per second	8·526	7·612
	Theoretical horse-power	31·05	15·182
	Horse-power per cub. ft. of free air compressed	·088	·0475
	Air horse-power	78·54	40·706
	Efficiency, per cent.	39·5	37·206

TABLE VI.—AIR LIFT TESTS AT CASON SLIMES AND SANDS PLANTS.

for stated conditions, sufficiently efficient to make it a healthy competitor of the ordinary tailings wheel, and it is proved, beyond ques-

tion, more suitable than the tailings pump. The capital cost of a duplicate equipment of air lifts is very low compared with that of wheels or pumps, provided low-pressure air compressors, driven from the mill shaft, are employed.

As the lifts and compressors would be in duplicate, the stoppage of work due to breakdowns of the pulp lifting devices is avoided, and one day's stoppage per annum would more than cover any increase in power costs. There is the further advantage that any large increase in the amount of material to be lifted does not necessitate the rejection of the plant installed, as tubes of sufficient capacity to meet the increased demand can be added to the installation, and two or more tubes run in parallel. Except as an emergency pump the air lift is too inefficient to replace power pumps for pumping clean, pure water. For dirty or acid water, sands or slimes, under comparatively low heads, it is a most valuable device, and, if properly arranged, is hard to beat. If not properly designed it is a tremendous power eater. This latter characteristic is well exemplified by the fact that if the contents of the well become aerated, through compressed air leaking back from the foot piece, a practically unlimited amount of compressed air will be absorbed by the lift, and the discharge from the tube will be of the nature of a fine spray blown out by the air. Under such circumstances it can be well understood that the efficiency of the plant would drop to an almost negligible quantity. It can be accepted as an axiom with air lifts that unless the discharge is a comparatively steady flow, free from pulsations, the best results are not being attained and, in all probability, the ratios of lift and submersion are not correctly proportioned.—*The Engineer*, London.

MINE VENTILATION

It is generally considered that a miner requires 20 cubic feet of air per minute, and a horse 90 cubic feet, but allowing for the air necessary to drive away fumes of explosives, the products of combustion from lights and other impurities, a much larger quantity of fresh air is required. In Prussia 70 cubic feet of air per minute is allowed for each man; the Victorian Mining Act requires the same amount. Pure air may be considered to consist of 79 per cent. of nitrogen by volume and 21 per cent. of oxygen. As a matter of fact, it also contains small quantities of other gases, chiefly carbon dioxide. One should aim at keeping the percentage of carbon dioxide as low as possible, and the oxygen above 20.5 per cent. Mine air may be fouled by gases given off by rocks and minerals, such as carbon dioxide, sulphurous anhydride, marsh gas from decaying timber, light, fuel, respiration of man and beast, perspiration, want of proper sanitary arrangements, and from blasting, which gives off carbon dioxide, carbon monoxide and nitrous fumes. An increase in temperature due to depth, heat from the body, combustion, exhaust steam, steam pipes, chemical decomposition—all require extra air to make life below ground healthy. Some of these vitiating causes may, and should be, greatly mitigated. For instance, proper attention to sanitary arrangements, the destruction of old timber and the barking of timber instead of leaving it to rot underground, and seeing that good explosives are employed and properly fired. The method of working a deposit may greatly facilitate ventilation. The problem of ventilating a lode mine is quite different to that of a bed mine such as a coal seam or deep lead. Lode mines are more or less vertical, and, from their nature, have several outlets to the surface; a bed mine is generally under cover, so that the inlet and outlet air has to pass through certain artificial passages which can be regulated as desired. To force air into or suck it out of an ordinary lode mine would cause short-circuiting unless pipes were used direct to the place to be ventilated, but in bed mining the cover generally acts as an effectual preventive for natural short-circuiting. Therefore, while it is fairly easy to supply a given quantity of air per man in a colliery, it is by no means so easy in a lode mine; for though the air may be provided at its source, in most cases it will be dissipated before reaching the desired point if discharged direct into underground passages. The ventilation of mines may be natural, assisted natural, or artificial. In difficult cases, artificial means have to be resorted to. These generally consist of some form of fan, which induces a large current of air at a low pressure. Certain principles governing ventilation may be laid down, but how they are to be applied depends on local conditions in each instance.

THE ATLANTIC OCEAN AS AN AIR COMPRESSOR

The tides in their rise and fall suggest in that action an unlimited and unfailing source of power. The utilization and convenient employment of this power has been an engineering problem of the ages, and up to the present little practical success has been achieved. The power, while costing nothing in itself, still must involve large expenditure for the arrangements made and the means employed for its development and transmission. One of the most interesting, and we may say also most promising of these schemes of utilization is that now under way at Rockland, Maine, under the impetus and direction of a competent and experienced engineer, Mr. W. O. Webber, of Boston, who has presented a concise account of his undertaking in a recent issue of the *American Machinist*. This account, somewhat abridged, we here reproduce.

This is not an application of the Taylor system of air compression, which has been so successfully employed at several waterfalls in different parts of the country, but is really a return to the older methods of Frizell, with modern improvements.

Careful experiments upon a large working model erected at South Thomaston, Maine, las summer, have fully demonstrated the peculiar application necessary to the utilization of the flow between large tidal basins and the ocean, and have demonstrated that an economical compression of air can be accomplished with much less differences in water level than was claimed by Frizell. At South Thomaston, Maine, there is a tidal basin with an area of slightly over a square mile. The average rise and fall of the tide at this point is 10 feet. This would, therefore, realize about 5,000 horse-power on the basis of 75 per cent. efficiency of the compressing apparatus, which should be easily obtained, as the tests of the other plants mentioned have given much higher values.

The "head of fall," or the difference of level in the case of tidal flow, simply governs the ratio of air that can be entrained with a given volume of water, and has nothing to do with the pressure. The depth below the surface at which the separation of the entrained air from the water takes place, governs the pressure, and it has been demonstrated that with a fall of 35 feet the highest ratio of efficiency can be obtained, that is, the maximum ratio of air to water.

It is easily practicable to arrange for storage chambers, connected with the separating chamber, sufficiently large to store air to the average capacity of the compressor, to cover the period of time at flood and ebb tide when the compressor would either not work at all or at such low efficiencies as to be commercially worthless.

It is practicable to transmit compressed air through pipes to long distances with comparatively slight losses. The leakage is negligible. As hydraulically compressed air contains no entrained moisture, the frictional resistance is remarkably low, and velocities of 50 to 70 feet a second are admissible. The cost of pipe lines is not greatly in excess of electrical transmission lines when the cost of step-up and step-down transformers for high voltage is taken into consideration.

There are many tidal basins along the coasts of the temperate zones between the fortieth and fiftieth parallels of latitude which are commercially capable of development in this manner with an unfailing source of power. This power can be made available for many miles inland from the shore at a comparatively low cost and, with the single exception of lighting, can be turned into useful work in its original form in strict competition with electrical power.

Work will begin at Rockland early next spring on the construction of the dam, laying the pipe lines to the quarries of the Rockland Rockport Lime Company, to the power-house of the Rockland, Thomaston & Camden Street Railway and also to several cities in whose streets distribution mains will be laid the same as gas pipes. It is expected that the plant will be completed in the fall of 1908.

THE ROCKLAND DEVELOPMENT.

Fig. 1 shows details of the lock and inlet and outlet gates, Fig. 2 a partial general plan and section of the complete construction at the same point. The maximum tide is 10.6, mean tide 9.4 and minimum tide 7.9 feet, giving, respectively 5,000, 4,000 and 3,000 horse-power. In this dam, where the main channel is navigable, will be a lock for vessels 40 feet wide by 200 feet long and 28 feet deep. On either side of this lock will be one or more sets of shafts, each set making a unit or compressor of 1,000 or more horse-power. These shafts will be sunk into the rock to a depth of 203.5

feet below mean low water, the down-flow shaft being 15.75 feet in diameter, the up-flow shaft 35.65 feet in diameter. The inflow gates will be five in number and 10 feet wide. The outflow gates will be six in number and 10 feet 8 inches wide.

water and accumulate in the upper part of the separating chambers. The water will then flow up the up-take shaft at a velocity of 3 feet per second and out through the out-flow gates. The air entrapped in the air chamber is then under a head of water about 195.5 feet high,

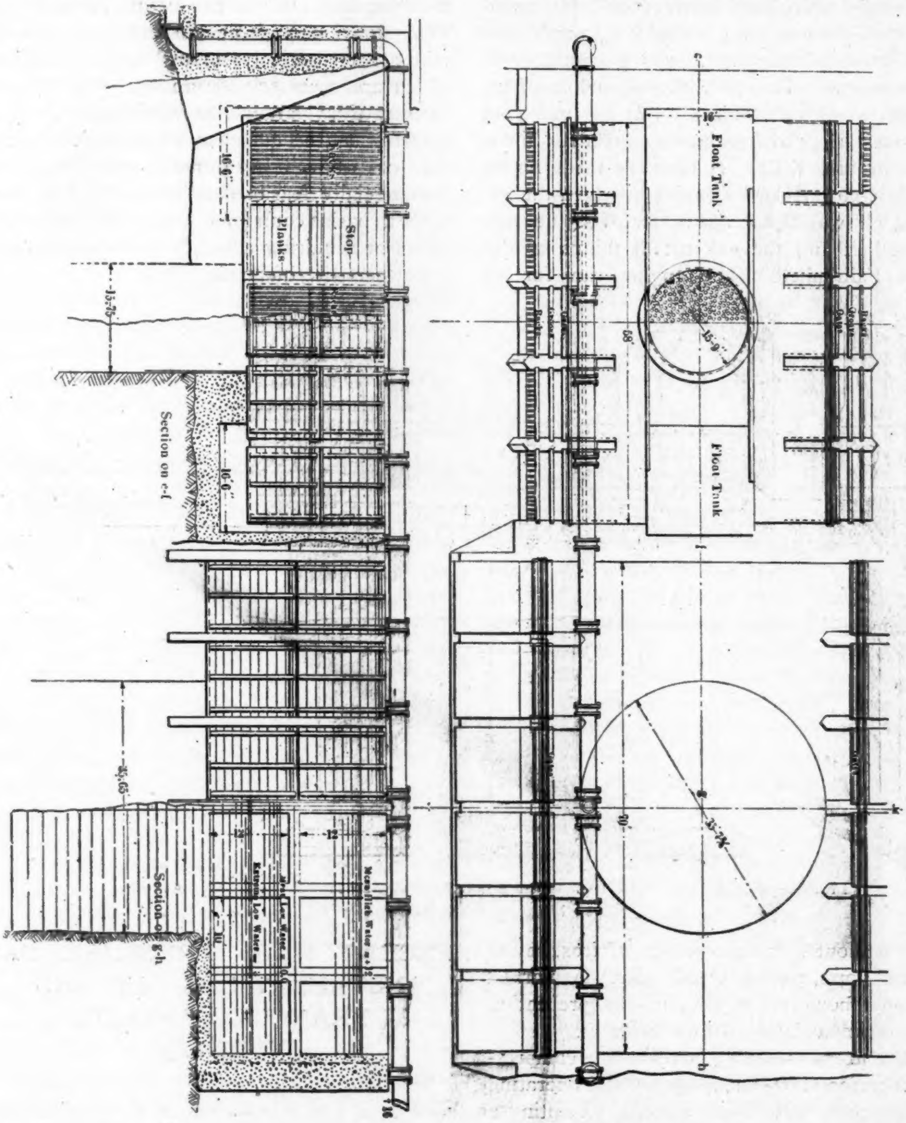


FIG. I.—DETAILS OF INLET AND OUTLET TUBES, TANKS, ETC.

The water on entering the inflow gates will swing them open, pass down the down-flow shaft at a velocity of 16 feet per second and draw in air through about 1,500 half-inch inlet tubes. At the bottom of the shaft the combined air and water will flow in both directions horizontally; the air will separate from the

varying slightly with the height of the tide. This compressed air is then led up the up-flow shaft in a 14-inch pipe. At the top of the gates these 14-inch pipes are united into a 30-inch main which conveys the air ashore.

The air thus compressed will contain only about one-sixth the moisture that is in the

atmosphere from which the air is drawn, owing to the absorption of the moisture in the compressed air by the surrounding water. This dryness makes the air particularly adaptable for transmission in pipes to a considerable distance without undue friction. For instance, the whole 5,000 horse-power could be transmitted a distance of 1 mile in a 30-inch pipe with a loss of only 1.5 pounds pressure, or 10 miles in a 48-inch pipe with only a loss of 2.5 pounds pressure. This air can be used cold without danger of freezing in expanding in engines or rock drills. A test was made on an 80 horse-power Corliss engine in which the entering air was at a temperature of 5.3 degrees Fahrenheit and the exhaust at minus 40 degrees Fahrenheit. The engine ran for 10 hours without the slightest sign of frost in the exhaust ports, passages and pipes. A marked economy, however, is obtained by preheating this air immediately before using it.

There are no working parts in the compressor, therefore little depreciation and operating expense to be taken into account, excepting a watchman to prevent depredations on the plant, keep ice, floating timbers and debris from permanently obstructing the inlet racks and to operate the boat lock. Therefore, the cost per horse-power is practically represented by the interest on the original investment and the wages of these watchmen. The cost of original construction will amount to $100 per horse-power.

It is a rather curious fact that, as a rule, in the temperate zones where the population is largest the maximum rise and fall of the tide occurs. This maximum tidal action results in the "wearing out" or excavating by means of tidal abrasion of basins in the coast, usually with a comparatively narrow outlet, conditions which are necessary for an economical development of a tidal air-compressing plant. Each acre of such basin under a 9-foot tide is capable of producing 5 horse-power. It is not commercially feasible to develop such a plant with a basin containing much less than 200 acres, or requiring a length of dam exceeding 3 feet per acre of pondage.

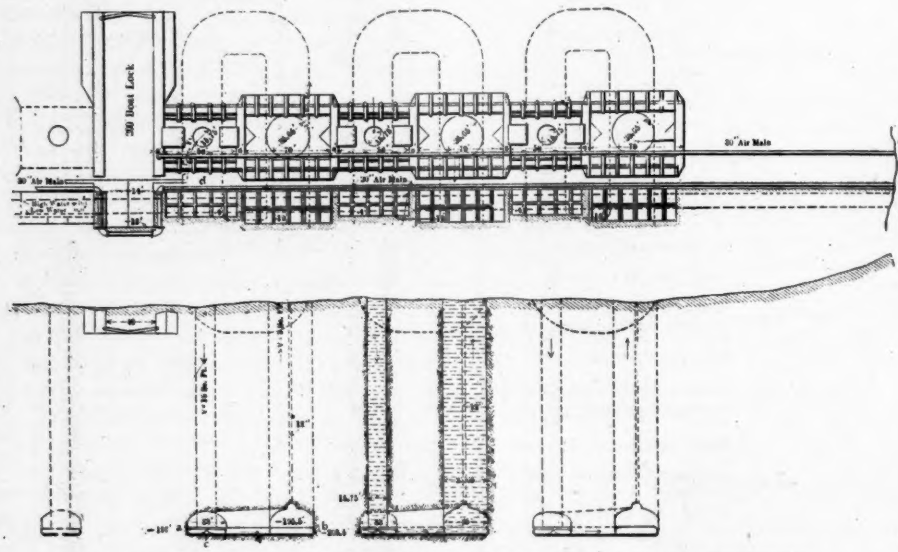


FIG. 2.—PLAN AND PARTIAL VERTICAL SECTION OF TIDAL AIR COMPRESSOR.

RECENT HIGH PRESSURE GAS INSTALLATIONS AT SAN FRANCISCO AND ITS VICINITY

The following is a paper, nearly complete, read at a recent meeting of the Pacific Gas Association by Mr. E. C. Jones, chief engineer, Gas Dept., California Gas and Electric Corporation and San Francisco Gas and Electric Company:

In the early days of gas lighting on the coast there was a small coal-gas works at San Mateo, twenty-one miles from San Francisco, and

later on an oil-gas plant was built at Redwood City. After the usefulness of high-pressure systems had been demonstrated, a high-pressure line consisting of 2½-inch extra heavy pipe, with line pipe sockets, was laid from Redwood City to San Mateo, 8.2 miles. On this pipe a pressure of from 10 to 30 pounds is maintained, depending upon the demand for gas. This line feeds into a high-pressure district in San Mateo, which includes 63,490 feet of 1 and 2-inch pipe. The consumers in this town are served with gas through high-pressure regulators at the inlet of each meter. This permitted the shutting down and dismantling of the San Mateo gas works.

A high-pressure system was also installed at Redwood City, consisting of 5,410 feet of steel pipe in small sizes. This is used in conjunction with a low-pressure system at Redwood City fed from the gas works by one governor, reducing the pressure to 4 inches of water. The work of compressing the oil gas at Redwood City was performed by a steam-driven compressor, with suitable governors for regulating the high pressure of San Mateo and the high and low pressure mains of Redwood City.

During the early part of 1905 Palo Alto, a city of 4,500 inhabitants, five miles south of Redwood City, was piped for gas with small, high-pressure mains, using individual governors. This work was done by the Palo Alto Gas Company. This new company purchased its supply of gas from the Redwood City plant. To supply this district, 3-inch outside diameter steel tubing, 26,365 feet in length, was laid in the country road, and four storage tanks, 29½ feet in length by 4½ feet in diameter, were installed at the Palo Alto end of the line.

In casting about for a suitable place to locate the storage tanks at Palo Alto, it occurred to the writer that it was not necessary to purchase or rent real estate for the purpose of placing gas storage tanks above ground, as many gas companies all over the world are occupying the streets with gas mains of greater diameter than these storage tanks. The tanks were, therefore, placed under ground in a tandem sequence closely surrounded by earth, the regulators occupying spaces between the tanks in neat boxes with covers flush with the surface of the ground. This arrangement is both safe, inoffensive and economical. This high-pressure line is operated under pressure varying from 40 to 60 pounds, and to insure continuous service it became necessary to install an electrically-operated compressor at the Redwood City plant, retaining a gas-engine-driven compressor as a reserve.

To improve the service, and to permit of better regulation, a storage tank was installed at the Redwood City works, and into this tank all the gas used by Redwood City, San Mateo and Palo Alto was pumped. The gas was liberated through separate governors, giving to each of the three places the required pressure. At that time the effect of compression on candle power was being widely discussed and was but little understood. All that was known was that the illuminating value of the gas suffered almost directly proportionally to the increase in pressure.

EFFECT OF COMPRESSION ON THE GAS.

It was evident that the raising of the pressure to 60 pounds on the Palo Alto line reduced the candle power 4.6 candles. The compression liquid, depending in quantity on thermal conditions and the amount of pressure, was being drawn out of the drips on the line. This liquid consisted of water, naphthaline, and a high grade of benzol. This benzol represented the cream of the candle power of the gas, and consisted of the least stable and most sensitive hydrocarbons which were squeezed out of the gas by compression.

The writer inferred that the compressed gas at 60 pounds pressure was nearly free from water, and was, therefore, in the best condition to readily and quickly take back into itself the hydrocarbons which had been squeezed out of it; also, that the hydrocarbons would more readily be taken up and again enter into the composition of the gas than the water would be, because the benzol evaporates so much more readily than does water.

The physical changes in the gas due to compression, and to the restoration of the candle power, are in the following sequence: The compressor squeezes out the water and some of the hydrocarbons, and, in order to replace the hydrocarbons, it becomes necessary to keep the gas in intimate contact with the fluid resulting from compression. To do this the writer designed an extremely simple piece of apparatus, and gave it the name of auto-enricher. It is a simple cylinder, preferably of large size, into which all of the compressed gas and the fluid of compression as they came from the compressor enter at one end at the

top, and the gas is taken out at the other end at the top, care being taken that the passage of the gas is slow, and that none of the liquid is allowed to escape from the auto-enricher except as it is taken up by the gas. Such a re-enriching tank was placed underground at the Redwood City plant, with the result that the candle power at San Mateo, Redwood City and Palo Alto was restored to its original condition before compression.

Further experiments (which were subsequently made the subject of a paper by the writer, read before the American Gas Institute) proved that, by raising the compression, certain physical changes took place in the gas, until at 300 pounds pressure the gas was completely purified from sulphuretted hydrogen and naphthaline, these going down with the compression fluid and not reappearing in the gas when the benzol is taken up by the gas in the re-enriching tank.

LARGEST OIL GAS PLANT.

In 1905 the largest oil gas plant in the world was designed and constructed, on new lines, at a point on the bay of San Francisco in San Mateo County, in close proximity to the San Francisco border line, and was named for our president, Martin Station. This plant was built for the purpose of supplying gas to a number of large gas engines for directly generating electricity. Before the completion of these engines the gas generating plant was finished and started.

To utilize this enormous plant a 12-inch steel tubing was run along the country roads into San Francisco, and connected with the works of the San Francisco Gas and Electric Company at the Potrero Station. The length of this line is 4½ miles, and a steam-driven compressor was used for transferring the gas. This proved so satisfactory that it became the nucleus of the largest compression plant for manufactured gas in existence. Two power-driven compressors were installed, each having a capacity of 5,500,000 cubic feet of gas in 24 hours. Following the growth of this plant, the gas engines, three in number, each of 5,333 horsepower, were completed and successfully started. Between Martin Station and the south is the high ridge of the San Bruno Mountains, but west from Martin Station there is a gap through the range, which permits of a practically level outlet into the county roads leading from San Francisco down the peninsula to the south. It required the earthquake, which is not yet effaced from our memory, to bring out the fact that Martin Station is a desirable point from which to supply gas to the cities and towns of the peninsula through high-pressure mains.

EARTHQUAKE-PROOF PIPING.

The peninsula towns were directly in the path of the earthquake's greatest destruction, but as the high-pressure mains and nearly all the distributing mains in this section were of wrought iron, not the slightest damage was done to the distributing system—this is true of all the high-pressure systems in California. No wrought iron pipe was broken and no joints were disturbed.

The Redwood City gas works, however, did not fare so well. The boiler settings were badly damaged, and the gas-generating apparatus was moved several inches on its foundation, while all cast-iron connections were more or less damaged. A 20,000 cubic foot gasholder, in a redwood tank, was completely demolished. This adjustment of matters by the earthquake made it much easier to decide to supply this district from Martin Station.

On February 23, 1907, the work of laying a 4-inch steel tubing from Martin Station to Redwood City, a distance of 125,295 feet, or 23.73 miles, was begun. The inside diameter of this tubing is 3.7 inches. This pipe passes through the following suburban towns, all of which receive gas from it: Burlingame, population 900; San Mateo, 4,600; Belmont, 500; Redwood City, 2,500; Fair Oaks, 250, and the Palo Alto extension, including Menlo Park, with a population of 1,200, and Palo Alto, 4,500, making a total population of 14,450.

This high-pressure line was laid with Dresser couplings, using rubber gaskets, the flanges of the joints being drawn up tightly and evenly to prevent the contact of the gas with the rubber as much as possible. It is quite important, in using this patent coupling, that the tightening of the bolts shall proceed evenly, so that the flanges may remain parallel. Should one side of the flange be drawn up more than another, the pressure on the rubber gasket is uneven, and the flange is apt to bind on the pipe so that a leak is almost certain.

The painting of this line was a matter of some study, as it has previously been found that red lead and linseed oil of the best quality,

although offering a good protection to the pipe, would not withstand the attacks of either air or the soil. This pipe was, therefore, first thoroughly cleaned and painted with one coat of red lead and oil, then given a second coat of a good and well-proven metallic gasholder paint which dries with a hard, shiny finish. It is hoped that this covering will be more durable than those formerly used.

A new pattern of drip-box was used on this line, and 25 of them were located at various low points throughout the length of the pipe. High-pressure valves made for the purpose of holding ammonia were placed in the line at five different points, at the approach of each town. These valves were connected into the line by means of an adapter to permit the connecting of a Dresser coupling with a flanged valve. The drip-box is provided with half a Dresser coupling on each side to facilitate its being connected into the line.

No other fittings are used in this line with the exception of six crosses, one at each town. These crosses are provided with adapters to Dresser couplings, and all right angles are turned by bending the pipe at a uniform radius of 20 feet.

At the completion of each day's work the line was capped and air pressure applied to it, up to 100 pounds per square inch. This pressure was allowed to remain on the line the entire night. Testing for small leaks was done by the use of soap-suds and a brush, the soap-suds being applied to all parts of the coupling and to the pipe for a distance of 2 feet each side of the coupling, as this seems to be the vulnerable place where the pipe is apt to be split.

TESTING FOR LEAKS.

One of the details developed in connection with testing for leaks is the fact that thick soap-suds, which has been mixed for several days, is better than soap-suds quickly and imperfectly mixed. The importance of careful testing is evident when it is stated that 182 defective sleeves and 29 lengths of split pipe were discarded on this line.

Much of the work was done during uncertain spring weather, and a plow could not always be used to advantage, so that it was necessary to do much of the work with pick and shovel. A grader was used for refilling, and all of the trench after being filled was carefully sprinkled and rolled.

The line was completed June 1, 1907. The actual working days required were seventy-five. The average amount of pipe laid each day was 1,660 feet, while the greatest amount laid in a single day was 3,200 feet. The average depth of the pipe is 2½ feet. The line was placed in commission Thursday, July 18, 1907, and not a single leak developed in any part of the line.

The gas is pumped into the line by a 14×16×12-inch steam-driven compressor, with a mechanical efficiency of 85 per cent., requiring 55 horse-power, under the present conditions. This compressor has a capacity of about 22,500 feet per hour. The gas is first forced through an auto-enricher tank, alongside of which is a storage tank.

These tanks are 6 feet in diameter by 32 feet long, and have a capacity of 875 cubic feet. The line itself has a capacity of 9,375 cubic feet. The 25 drips on the line have a combined capacity of 19 cubic feet, and the receiving tank at Redwood City, 380 feet. The total capacity of the tanks and line is 11,524 feet. The gas is received at Redwood City into a storage tank 5 feet in diameter by 26 feet long. This tank is used for receiving all the gas, and from it the various lines are fed through governors.

Four compression tanks, 6 feet in diameter by 32 feet long, are located at Redwood City, as a reserve storage to be used in the event of an accident to the compressing machinery, or on the pipe line. The gas is taken from the receiving tank and pumped by means of a motor-driven compressor into the four storage tanks at a pressure of 80 pounds. This boosting arrangement is a temporary expedient for present convenience, and is capable of many changes, as the storage tanks may be filled directly from the line and discharged automatically through the present governors whenever there is a drop in the pressure. At the present time, approximately 100,000 cubic feet of gas per 24 hours is consumed through the Redwood City high-pressure line, and the line is so free from defects, and the storage capacity of the line and the three tanks (disregarding the four storage tanks at Redwood City) is so large, that the compressor at Martin Station is only operated a portion of the time.

This 4-inch O. D. line has an actual capacity at 5 atmospheres, or 58.8 pounds pressure, of 57,620 cubic feet, or an available capacity at that pressure of 46,096 feet. In speaking of atmospheres in reference to pressure, it must

be remembered that when we say that we have 5 atmospheres in a tank, we do not mean five available volumes of the tank, but four available volumes, and 58.8 pounds gage pressure, there always being one volume or atmosphere that is not available or apparent on the gage, and which cannot be gotten out except by exhausting the tank to a vacuum, or filling it with water.

This line completely installed cost 1½ times as much as a 2-inch outside diameter line which would have an actual inside diameter of 1.782 inches. It has an actual holding capacity of 4.3 times as much as a 2-inch O. D. line, and its carrying capacity at equal pressures is 5.75 times that of the 2-inch O. D. line.

This installation is amply large to provide for the growth of the southern suburbs of San Francisco for many years, and will insure excellent service to the best class of gas consumers, the average monthly consumption per meter of these consumers being 4,570 feet, which is in excess of that of most of our large cities.

In conclusion, the writer may be permitted to apply a very old saying to high-pressure gas distribution, that, like fire, it is a good servant, but a bad master.

PURIFICATION OF SEWAGE AND POLLUTION OF ATMOSPHERE

Disagreeable though it may be to the average person, the damp and unpleasant atmospheric conditions which prevail in Lancashire are the county's chief asset. But although a humid atmosphere may conduce to successful cotton spinning, there is, fortunately, no necessity for a solid element in the air. The paper read in Manchester recently by Mr. R. H. Clayton shows that by analysis the polluting matter in Manchester air approximates most nearly to that of the smoke from domestic chimneys, being charged with tarry oils, ammonia and solid ash, which are only emitted from boiler chimneys in insignificant quantities. The author demonstrated the resemblance which exists between the domestic firegrate and the gas retort in the process of distillation of the fuel going on in each, but with the essential difference that the products of distillation are in the case of the household fire-grate poured into the atmosphere, while in the retort they are collected and used as valuable industrial materials. As an argument in favor of domestic gas fires Mr. Clayton made the significant statement that while on the one hand the citizens of Manchester spend annually £64,000 on the purification of sewage to prevent the pollution of rivers, yet, on the other hand, the purification of the atmosphere was retarded by the city fathers by charging for municipal gas such a price that an annual profit of £60,000 from its sale was set aside for the relief of the rates.—*The Engineer, London.*

A RECORD JUMP IN BRIDGE DESIGN

The fall of the uncompleted Quebec bridge was the disastrous event by which the year 1907 will be recorded in the history of bridge building. It points to a danger of engineering conceding too much to commercialism. The company had a certain amount of money, and wanted a great bridge built within the limit. That is not the way in which monumental works are erected.

* * * * * * * *

Designs have been made for a reinforced concrete arch bridge which exceeds the Quebec bridge in boldness. While the present largest masonry arch bridge is less than 300-foot span, and the largest concrete arch bridge only 233-foot span, the new design is for a clear span of 703 feet. It is the main span of a proposed Hendryk Hudson Memorial Bridge, to cross the Spuyten Duyvil Creek in New York City. The designs call for a concrete rib 70 feet wide, 28 feet thick at the haunches, and 15 feet at the crown, with spandril arches to carry the roadway. The rise is 177 feet. The compressive stress on the concrete is limited to 750 pounds, and the amount of steel required for reinforcement in compression is said to be greater than for a steel arch bridge. The difficulties of erection at the site are extreme, and the Quebec bridge investigation has shown that while it is easy to design a bridge in the drawing office, the matter of erection can not be overlooked with impunity. The failure of the Quebec bridge might well give pause to the office designer or engineer who plans a concrete arch of 700 feet span when nothing larger than 233 feet has yet been attempted.—*The Engineer* (London).

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Established 1896.

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PUBLISHED BY THE

COMPRESSED AIR MAGAZINE COMPANY
EASTON, PA.

New York Office, Bowling Green Building.
London Office, 114 Queen Victoria Street.

Subscription, including postage, United States and Mexico, $1.00 a year. Canada and abroad, $1.50 a year.. Single copies, 10 cents.

Those who fail to receive papers promptly will please notify us at once.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

Entered as second-class matter at the Easton, Pa., Post Office.

Vol. XIII. MARCH, 1908. No. 3

CONTENTS.

THE SCOOP VICE

In the chronicling of the events of the day, which are to be forgotten to-morrow, and accounts of which are absolutely valueless if not fresh, the struggle is always to get the news first, and if at the same time one can have the exclusive rush of it this is the supreme triumph of the reporter and the editor. The scoop is rightly the brag of the daily news man, but what has it to do with the collector and disseminator of permanent and especially of technical information? Such matter is really as good to-morrow or next week or next month as to-day, and yet the scoop habit of the daily press lingers with the conductors of technical periodicals, with the result that in many cases their readers are defrauded of their rights.

The conductor of a technical publication, such, for instance, as COMPRESSED AIR, or any other, the lines and limits of which are defined with reasonable clearness, is understood to have a standing and continuous promise to its readers and supporters to keep them informed and up-to-date in the special lines indicated by telling them all, properly sifted, of course, that comes to their knowledge or which they can procure concerning the new methods and means as they are continually developing and by way of stimulus about the rates of accomplishment which are constantly advancing. Any publication which deliberately withholds from its readers any matter of importance which has just become ripe for publication merely because it cannot have the first or the exclusive handling of it is not treating its constituents honestly, and after long observation of the practice we fail to discover the policy of it.

We were flattering ourselves that while we are not free from human weaknesses we were not afflicted with this particular vice when along came the article with which our present issue begins. If we could be tempted and led away we would be exulting and peradventure boasting over the fact that we are the first to publish the matter therein contained. There is no need of our calling attention to the fact that the making of liquid air cheaper than beer and by means which must be entirely approved by both the scientist and the mechanic is a notable achievement. Liquid air may now be produced in such quantities and at a cost so low that a large field for its employment is thrown open in the production of both oxygen and nitrogen in large volume for various in-

dustrial purposes, and other uses must inevitably develop.

The second long article in the present issue, with apologies and regrets for the length in each case, gave a more pertinent illustration of the possible working of the scoop vice. It happened that the reports of the tests of the Air Lift in South Africa came to the editorial office of COMPRESSED AIR a couple of months ago and were in process of preparation for our columns when the article embodying the same material appeared in admirable form in *The Engineer*. If the scoop vice had been in complete ascendency in this office the matter would have been dropped at once, but instead we reproduce the entire article of *The Engineer*, and our readers surely have nothing to regret.

PROGRESS ON THE RAND

The two paragraphs below are from the latest-to-hand issue of *South African Mines:*

AIR PIPES AND PRESSURES.

Some weeks ago we published a series of tables showing the carrying capacities of underground air pipes of various sizes for various distances, and we are gratified to find that, largely through our efforts, the whole question of the flow of air in pipes has of late attracted increased attention, and that reforms in this direction are at hand. Before our articles appeared, however, we understand that several of the mechanical engineering departments of the groups had also begun to investigate the matter; and the net result is likely to be shown in an early increase in the capacities of air pipes in the majority of our mines. We are informed that a paper which Mr. Laschinger is to read to-night before the Transvaal Institute of Mechanical Engineers, will contain a criticism of some of our figures; but that is a form of criticism which we would vastly prefer to no criticism at all.

PNEUMATIC RIVETERS.

The introduction of pneumatic riveters at the Simmer Deep plant construction works is a noteworthy addition to the long list of labor-saving appliances in use on the Rand. While the mechanical engineers of the Consolidated Gold Fields cannot, as far as these fields are concerned, lay claim to have discovered the utility of pneumatic machine tools, as the East Rand Mines have already adopted them, the new departure at the Simmer Deep reflects credit on the enterprise of the engineers responsible. Most satisfactory results, we understand, are being obtained from the use of the riveters on tank work, and the saving is estimated at over 50 per cent. in labor, and upwards of 60 per cent. in cost. The mechanical talent embodied in the invention of pneumatic tools is of the highest order, and is generally regarded as the greatest contribution to methods of machine-shop work made during the closing decade of the nineteenth century. Obviously, exact data bearing on the saving rendered possible are not yet available, but elsewhere, in addition to vastly superior workmanship, a direct economy of as much as 66 per cent. has been obtained from the use of the pneumatic riveter, from which has to be deducted the cost of compressed air, which may be placed at a maximum of 15 per cent.

THE FATAL BENDS

Unusually sad seems to have been the fate of George Harris, a young Englishman, who died the other day in the emergency compressed air hospital connected with the East River tunnels of the Pennsylvania railroad. Harris, who was 29 years old, had been in business in London and is said to have had considerable experience in the sinking of tubes for foundation work. He had been married six months and gave up his business to come to this country, being lured by glowing suggestions of rapid advancement. His testimonials secured him immediate employment as foreman of a night shift in the tunnel. He had been in the country with his young wife only a week when he went on duty. The reports in the daily press seem to suggest that he remained under pressure for an unusually long period. Upon coming out early in the morning he was seized with the "bends," and he was at once placed in the graduated pressure emergency hospital in connection with the tunnel workings. Here he was treated with all the skill procurable, but after a struggle of 30 hours death came and ended all.

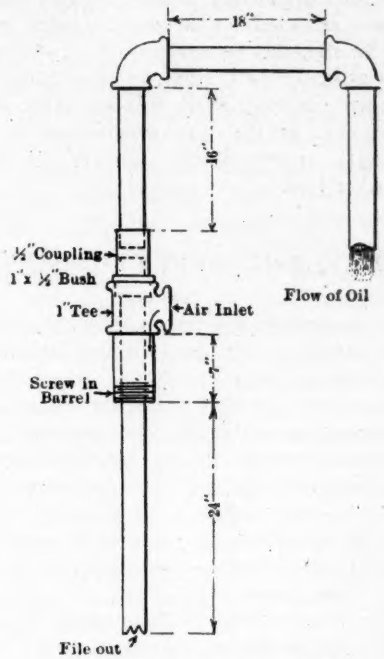
PREHEATING AND INTERHEATING COMPRESSED AIR.

Owing to the small size and portability of rock drills preheaters are for this service out of place, but for large hoists and pumps, with high-pressure air, they are always to be rec-

ommended. In the operation of the preheater the compressed air passes through a vessel containing heated tubes of sufficient radiating surface for the purpose. These tubes may be heated by a coal, coke or oil fire, but, since smoke contaminates the atmosphere of the mine, steam heating is often both convenient and economical. In an air heater it is possible to utilize steam more efficiently than in the best condensing engine, for both the latent and visible heat of the steam are absorbed by the air and turned into work without frictional losses greater than the motor would suffer with unheated air. With steam heating the only important loss is that due to radiation in the supply pipe from the boilers, and by proper covering this can be made small. In the 500-gallon Dickson pumps, installed in the Anaconda mines at Butte in 1899, the air was successfully heated by steam in both the preheaters and the interheaters for the compound cylinders.—*Engineering and Mining Journal.*

PUMPING OIL BY COMPRESSED AIR

The cut herewith, which we take from *Power,* shows a handy and efficient home-made device used, where a supply of compressed air is available, for pumping or forcing oil out of barrels. A 1-inch tee has a piece of 1-inch pipe 7 inches long screwed into one end of it, the other end of this pipe being screwed into the bung of the barrel, a 1⅛-inch hole being bored in it for this purpose. In the other end of the tee is screwed a 1x½-inch pipe bushing, the bushing having a straight screw thread all through it. A piece of ½-inch pipe 35 inches long with some notches filed across one end is passed through the 1-inch pipe and screwed into the 1 by ½ inch bushing from the inside, the thread on this pipe being cut long enough to screw up through the bushing and take a ½-inch coupling. The delivery pipe may be screwed into the coupling as shown or otherwise as most convenient. An air hose is connected to the side of the tee with a valve for controlling the pressure. When the 1-inch pipe is screwed into the bung the end of the ½-inch pipe comes close to the lower side of the barrel. When the air is admitted it passes down between the ½-inch and the 1-inch pipe and forms a pressure in the barrel which forces the oil up the ½-inch pipe until the barrel is entirely emptied. As only a light pressure is required, the air should be admitted quite carefully or with only a small valve opening.



FOR PUMPING OIL BARRELS.

COAL MINED BY MACHINES IN THE UNITED STATES

The percentage of increase in the production of machine-mined coal in 1905 over 1904 was greater than the percentage of increase in the total production. In 1906 the quantity of machine-mined coal was 15,451,075 short tons greater than in 1905, while the total production of bituminous coal increased 21,534,643 tons, showing that 72 per cent. of the increase in 1906 over 1905 was in the machine-mined product. The statistics also show that the average output for each machine in use increased from 10,258 tons in 1904 to 11,258 tons in 1905, and to 11,638 tons in 1906. The total quantity of coal produced by the use of machines in 1906 was 118,847,527 short tons, as against 103,396,452 short tons in 1905, and 78,606,997 short tons in 1904. The increase in 1906 was 15,451,075 short tons, or 15 per cent. The increase in 1905 over 1904 was 24,789,455 short tons, or 31.5 per cent., while that of 1904 over 1903 was only 623,103 tons, or 0.81 per cent. The num-

ber of machines in use increased from 7,663 in 1904 to 9,184 in 1905, and to 10,212 in 1906. The percentage of the machine-mined tonnage to the total production in the States in which machines are used has increased steadily each year. In 1899 this percentage was 23; in 1900 it was 25.15; in 1901, 25.68; in 1902, 27.09; in 1903, 28.18; in 1904, 28.78; in 1905, 33.69; and in 1906, 35.1. Of the 10,212 machines in use in 1906, 5,911, or 58 per cent., were of the pick or puncher type.

ACETYLENE SAFETY-LAMPS*

By L. H. Hodgson.

After numerous experiments, extending over several years, a safe and efficient acetylene safety-lamp has been introduced. It will only be necessary to point out the slight differences of construction as regards the treatment of the calcium carbide in the benzine safety-lamp. The oil-vessel becomes the receptacle for the calcium carbide, and is filled two-thirds full, thus allowing one-third for the expansion of the carbide when saturated with water. The upper vessel or the water-container is fitted with a filling aperature, an internal friction-igniter operated from the outside, and a water-and-gas shut-off, which comes into action separately, that is, when the outside lever is turned 45 degrees from left to right, the water is shut off and no further generation of gas takes place, but the lamp continues to burn and the residue is consumed in a few minutes; but should the lamp need to be instantly extinguished, the lever is turned the full 90 degrees, or as far as the lever will go. The gas thus inclosed gradually escapes through the by-pass. A safety-valve or by-pass is placed adjacent to the burner. Should the lamp be required immediately after it is extinguished, it is advisable to allow, say, five seconds to elapse before bringing the internal friction-igniter into operation, as the pent-up gas issues with extra velocity, producing, when lighted, a slight puff, which is detrimental to the wire-gauzes. The attachment of the two vessels is very simple: two staples on the side of the water-vessel are brought under two projecting buttons fitted on the carbide-container, and the vessels are firmly connected by pressing down the shank. A gas-tight joint is made with the aid of an india-rubber ring, inserted in a groove running round the circumference of the water-vessel.

The lamp has a flame which is of 10 candle-power. The flame is capable of being reduced at will, and, with 1 per cent. of fire-damp, there is a clearly defined blue cap surrounded by a greenish-yellow halo; while, with 3¾ per cent. of fire-damp, there is a well defined cone, with a hemispherical base, of a clear, luminous, greenish-yellow tint.

The period of burning varies from 6 to 12 hours, according to the size of the lamp. The carbide-chamber, for 6 hours' burning, when three-quarters full, contains 4 ounces. Carbide may be purchased in quantities at 6 cents per pound, and consequently the cost will be 0.25 cents per hour, per 10 candle-power, or 7.5 cents for five shifts of six hours.

The large acteylene safety-lamp, of 60 candle-power, is fitted with a water shut-off, which considerably assists in the economical burning of the lamp, as hitherto, it has been necessary to regulate the charge of calcium carbide to the time that the lamp is required to burn. The carbide-chamber, for 20 hours' burning, is filled with 3¼ pounds. The cost of burning is slightly less than 1 cent, or 0.016 cents per candle-power per hour.

COMBINED PUMP AND AIR LIFT

The following, signed "Chief Engineer," Washington, D. C., comes from a recent issue of *Power:*

The peculiar condition suggesting this arrangement was the need of water on the top of a mountain some 700 feet above the source of supply, a spring at the base of the mountain giving about ten gallons a minute. The distance and the difficulty in getting to and from the spring made it undesirable to locate a gasoline engine and geared pump at that point. Besides, the flow was so limited that to keep a man there for the length of time necessary to get enough water pumped up the hill would make the water very expensive. The operating conditions would be severe, too, for a plant located in an out of the way place, the pump working against something like 350 pounds pressure. The lower one-third, at least, of the piping would have to be extra heavy and well put together.

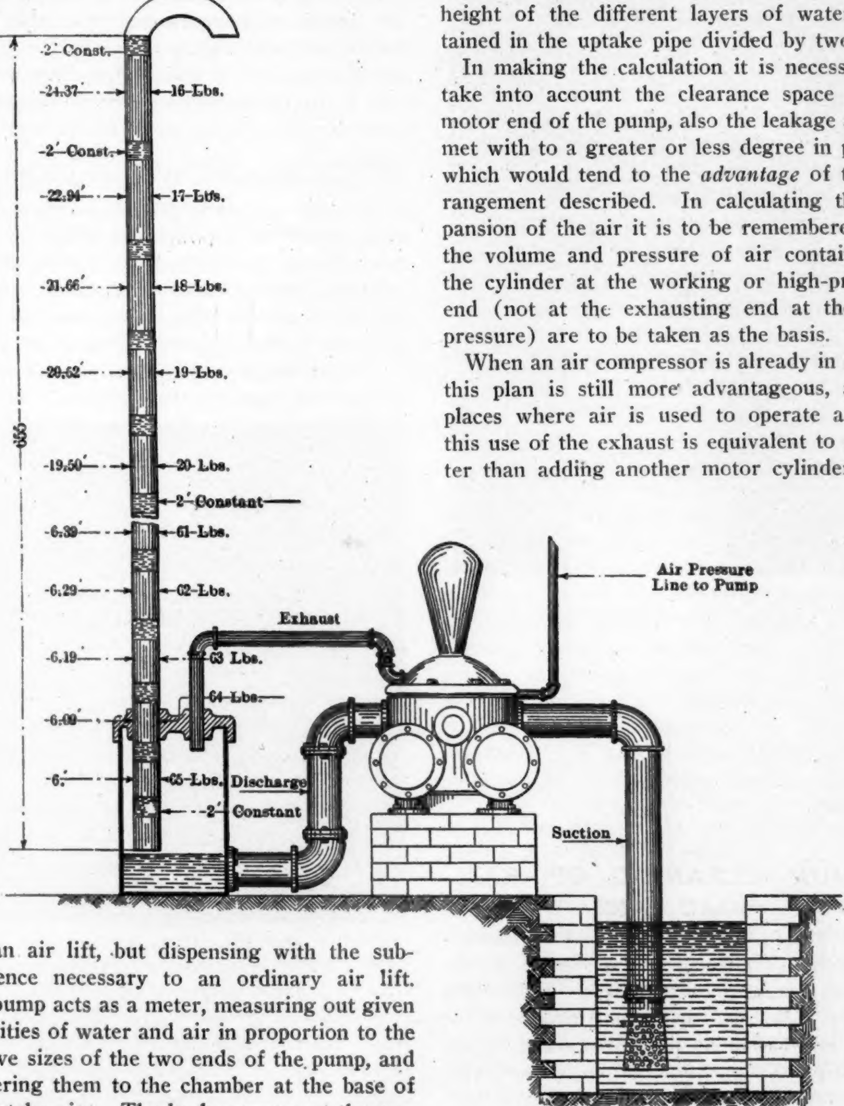
The installation adopted consists of a gasoline engine-driven air compressor outfit located on the top of the mountain, near the residence or barn, where the cost of equipment and attendance is minimized. The air pipe from the compressor is connected to an ordinary direct-

acting steam pump (duplex or single) located at the spring, the air taking the place of steam (this arrangement is common in mines), but instead of exhausting into the atmosphere, the exhaust is led into the top of the chamber shown, into which the pump also discharges the water at the bottom.

When in operation the water and air ascend in the uptake pipe in alternate layers exactly like an air lift, but dispensing with the submergence necessary to an ordinary air lift. The pump acts as a meter, measuring out given quantities of water and air in proportion to the relative sizes of the two ends of the pump, and delivering them to the chamber at the base of the uptake pipe. The back pressure at the motor end of the pump is identical with the back pressure in the high-pressure cylinder of a compound pump or engine, but instead of completing the expansion in another engine cylinder it expands in the uptake pipe, as it travels upward between two layers or pistons of water, in proportion to the total number of feet of water above it. The space required by the air in the uptake pipe reduces the number of feet of water contained in the pipe, so that the pressure against which the pump works and the back pressure against which the motor end exhausts approximately equal the sum of the height of the different layers of water contained in the uptake pipe divided by two.

In making the calculation it is necessary to take into account the clearance space in the motor end of the pump, also the leakage always met with to a greater or less degree in pumps, which would tend to the *advantage* of the arrangement described. In calculating the expansion of the air it is to be remembered that the volume and pressure of air contained in the cylinder at the working or high-pressure end (not at the exhausting end at the back pressure) are to be taken as the basis.

When an air compressor is already in service this plan is still more advantageous, and in places where air is used to operate a pump this use of the exhaust is equivalent to or better than adding another motor cylinder, i. e.,



COMBINED PUMP AND AIR LIFT.

using a compound pump. It is superior to the air displacement system of pumping and in many places superior to the air lift system.

A COAL DUST PHENOMENON

At a recent meeting of the Midland Institue of Mining, Civil and Mechanical Engineers, held at Doncaster, England, Mr. J. Neal read a paper describing the ignition of coal dust in the Beeston seam at the Middleton Colliery. The seam was a very dry one, and dust accumulated very rapidly. Early in September last a deputy had opened a safety lamp at the lamp station. A train of full tubs, drawn by a pony, was passing, and raised a considerable quantity of dust. Just before the train reached the lamp station the deputy removed part of the burning "snuff" from the wick of the lamp, and it fell harmlessly to the floor. As soon as the train had passed he knocked away the remaining portion of the snuff, and as this fell to the floor there was an ignition of the coal dust. The flame rose to a height of about 2¾ feet, and spreading over a width of 3 feet, followed the train with a peculiar rolling motion, apparently corresponding with the successive clouds of dust raised, making a peculiar hissing sound. The train stopped about 45 feet beyond the lamp station, and when the flame reached the last tub it ascended to the roof, returned along the upper portion of the roadway, and finally extinguished itself within 3 feet or so of the point of ignition. The color of the flame was described as being similar to that of a candle or oil lamp. Mr. Neal observed that mining engineers had thought that nothing short of an ignition or an explosion of gas, or gas and dust, could cause a coal dust explosion, and that was his opinion until this incident occurred.

VACUUM CLEANING OF RAILROAD CARS

The Chicago, Milwaukee & St. Paul Railway in a series of striking advertisements in the November magazines is calling itself "The Sanitary Way," and the reason therefor is the recent installation at the "Milwaukee" yards in Chicago of a vacuum equipment for cleaning the upholstery, carpets, curtains and bedding. "By its tremendous suction force," read the railroad's advertisements, "it removes dust, dirt, grit and germs as no other method can." The vacuum system was adopted after a series of tests lasting for several months. After cars had been blown by compressed air they were "vacuumized" and the dirt sucked out was weighed, with the result that from 1 to 2½ pounds of dirt could be "vacuumized" out of the plush and carpets. A thorough "vacuumizing" once every third or fourth trip keeps the car in better condition than if it were "beaten" or blown every trip. A rapid dusting on intervening trips is enough to keep the dust from accumulating. The labor saving nature of the device is shown by the fact that the first machine installed at the Western avenue yards of the C. M. & St. P. enabled the yard foreman to cut down his payroll $100 a month.

Under the aero air cleaning system, as it is called, the vacuum is produced by means of a compressed air aspirator, drawing its power from the air pipes which are laid through the yards for testing brakes. When the workman using the vacuum apparatus passes the cleaning tool or nozzle over the surface of a cushion or carpet the dirt is quickly sucked through the vacuum hose into the dust tank. This tank is mounted on wheels and is readily brought alongside the car to be cleaned. The aspirator is attached at one side of the tank. Inside is a separator which collects all the dirt. The cleaning is all done inside the car and without raising any dust.

DRYING

Things to be dried must contain moisture, and the process of drying is the vaporization of this moisture and its transfer into surrounding space. If the air filling this space is confined it becomes saturated and the drying stops. If the moisture is to be continually carried away the air which is the conveyor must be kept constantly moving. Heat is merely a useful accessory to decrease the time of drying by increasing both the rate of evaporation and the absorbent capacity of the air. Air is not necessary and the space may be a vacuum; under either condition a certain space will take up a stated weight of vapor. When vapor is diffused in air the vapor molecules occupy their own displacement in addition to the space occupied by the dry air. Less air is contained in a given space if saturated with vapor than if dry, and yet the specific gravity of the moist air will be lower than that of dry air of the same temperature because vapor

is lighter than air at the same pressure and temperature. If a certain space is saturated with vapor when at a certain temperature, an increase of temperature will increase the capacity for moisture, but if the temperature is lowered some of the vapor will be deposited. The temperature at which deposition begins, is called the "dew point," and it depends upon the initial degree of saturation of the given space, the less the relative saturation the lower the dew point. Heat is such a valuable agent in the drying process because it changes the capacity of air for absorption, the amount of vapor a given space will contain increasing rapidly with the rise in temperature.

THE SOBLIK PNEUMATIC TYPEWRITER

The typewriter shown in the half-tones, carrying the name of the inventor, has been described recently in *La Nature,* Paris, by Dr. Alfred Gradenwitz. The operator touches the keys to indicate the letters, but no appreciable force is required, and the fatiguing work of

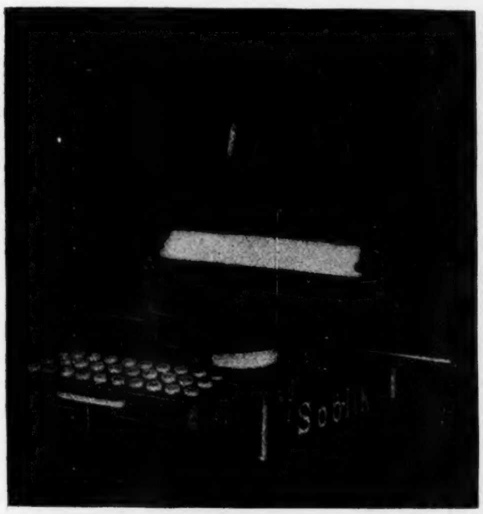


FIG. I. THE SOBLIK AUOTMATIC TYPEWRITER.

protracted operating is annihilated by the pneumatic devices which supply the necessary force.

The keyboard of the machine has several rows of buttons with a corresponding opening for each in the cover of a rectangular air box, each opening connected by a small tube with the center of the machine where the type wheel is placed. The rim of this wheel, carrying characters in raised type, is rotated until the letter indicated is brought into position, and the impression is made by thrusting out the letter to strike the surface of the paper. The pneumatic action gives a uniform pressure for each letter independent of the action of the operator, and this pressure may be adjusted by the movement of a lever according to the

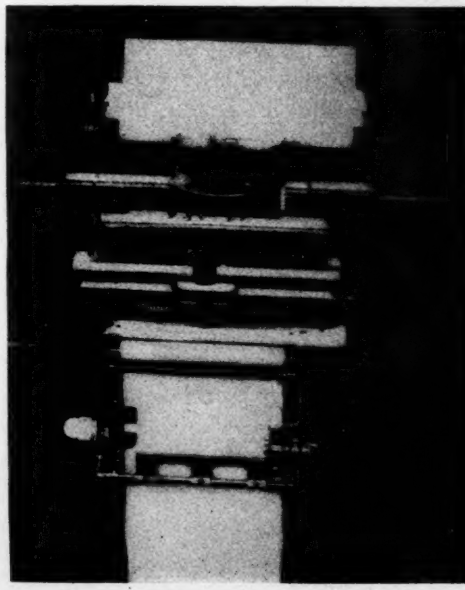


FIG. 2. PNEUMATIC TYPEWRITER WITH AUTOMATIC MULTIPLIER.

requirements of the work in hand. When a large number of carbon copies are being made the operator has no more effort to make than when a single impression is made. By pressing other buttons the carriage is brought back to the beginning of the line and the spacing for the next line is adjusted.

In this machine several buttons may be pressed at once and the letters will be correctly printed, provided they follow in alphabetical order. Syllables or entire words may thus be printed by a single touch.

The inking of the characters is similar in operation to that of a printing press. The ink may be changed at once without changing the types or any risk of soiling the paper with too much ink.

The air used to operate the machine is compressed by a minute electrically operated com-

pressor. The machine may even be run by blowing into the tube.

The types are rather pressed against the paper instead of striking it, so that there is no appreciable noise from the operation. The writing is always visible. The weight of the machine is about 15½ pounds and the dimensions are 12x10x6 inches. An automatic multiplier, seen in Fig. 2, may be used with the machine. This is below the keyboard and produces a perforated pattern upon another sheet of paper. When the writing is finished the perforated record may be used to reproduce as many copies as may be desired.

BEGINNINGS OF SUCCESS IN FLIGHT

I was lucky enough to study at leisure the trial flights of Henry Farman for winning the $10,000 prize which he earned so well. He was to fly on his aeroplane a half-kilometre (one-third of a mile), then turn a goal and return to the starting point—all without once touching ground. The length of this irregular oval around which he took his course in mid-air was full three-quarters of a mile; and, since his victory, out of pure lightness of heart, at a motor working well, he has made a circular flight three times as long. Not enough has been said of the mere look of man and machine as they "plane" against the sky; for a new verb is needed to describe the motion.

It is like nothing else ever seen before. It is not even like Santos Dumont's little dirigible baloon—the "No. 9," which carried him back and forth so easily from place to place in the Bois de Boulogne, like an automobile running through the air. Small as its gas bag was, the "No. 9," like all balloons, kept the look of being suspended by something, held up in the air as it glided about. On the other hand, the biggest kite shows always by its movements that a string is holding it down. Farman's aeroplane moves like neither the one nor the other; it does not even resemble a giant bird cutting through space, any more than an automobile resembles a horse.

It is a vast human structure, as evidently a machine as a steam engine, with its spread of box-like cells and whirring motor and place for the pilot in the middle. Its flight through the air in long rising and falling curves, as the motor varies its power, is graceful beyond measure, but thoroughly human—just such a mechanical grace as that of a motor launch over a broad expanse of water.

Soon the sight will become as common as any other; for men have found what Clerk Maxwell called in electricity the "go" of the thing. Farman knows now just how many pounds' weight his motor will take up into the air and how long a flight. The motor's the thing.

THE KEY TO SUCCESS.

All these steady advances, however slow, were made possible by Santos Dumont's daring in hitching a petroleum motor to a balloon. I was also lucky enough to follow his very first experiments, only ten years ago. He had to face the entreaties of anxious friends and the open scorn of professional men of the air. He went on his way, year after year, undiscouraged by repeated failures; but he made of each failure a trial experiment of his principle, which he was sure was right. Thanks to his experiments, we have now two branches of an already practical industry—petroleum as a means of transport through the air. There are the great motor balloons for war; and there are these machines like Farman's, without any gas to help them, flying of themselves by the propulsion of a petroleum motor. The world has moved within that space of ten years; but human nature—in critics, in the crowd always too much in a hurry, and luckily in mad or inspired inventors paying no attention to either—remains a constant quantity.

No fair man can doubt that these flying machines will be made practical—little by little, like everything that comes to stay. They are here now for learning and sport. Soon rich amateurs will use them for their luxurious pleasure. Last will come their plain, everyday use when time and constant experiments shall have made known their possibilities. Even we, who by this vision splendid are on our way attended, may live to perceive it die away and fade into the light of common day. So was it with our prehistoric grandfathers when they saw the first wheel turning round an axle and rolling, instead of grinding its way, along the ground. So was it with those who looked on the first man that girdled his robustious heart with triple brass enough to embark in a frail raft on the cruel sea. We have slipped a notch in Time; and it is worth noting before it is forgotten.

PROGRESSIVE PRIZES.

The prizes which stimulate to experiments like Farman's have been graduated here in

France with great good sense. Instead of asking a brand-new, still uncertain invention to be put in competition with motor locomotion long practised on terra firma, the first prize was for flight in a straight line for a distance long enough to prevent skeptics saying: "Pooh! that was only a great bound in the air." Santos Dumont won this first prize last autumn, just as he was the first—publicly—to steer a balloon.

Then M. Deutsch (the same who gave the $20,000 won by Santos by steering his balloon from Saint-Cloud round the Eiffel Tower and back) and M. Archdeacon offered the prize which Farman has just won. The task was to fly a moderate distance and turn in the air and return to the starting point.

Now M. Armengaud, an engineer of international reputation and an authority on aeronautics, offers $2,000 to the man who will fly on his aeroplane for one-quarter of an hour without touching ground.

First, to fly at all; then, to steer the flight; now, to prolong the flight—these are the natural beginnings, even with a bird learning to fly. In due time will come long distance flights; starting and landing and steering matches; then other exercises of skill; and, the crown of all, as with the horse, with automobiles, with transatlantics—races. This is a practical order of things, instead of summoning the inventor first off to do everything at once or for ever after to hold his peace.—S. D. in *Evening Post* (New York).

CHLORIDE OF CALCIUM INSTEAD OF SALT

Chloride of calcium is being used more and more instead of salt in refrigeration, and those who substitute it for common salt will never go back to the other. Salt always contains a large amount of impurities, and its iron-destroying effect makes it rather costly in the end. It should be borne in mind that when a pipe is attacked from both sides its life will be rather short. This is also the case with the tanks containing the salt brine, and with pumps for handling it. This, as well as the great majority of other troubles that are experienced in using salt brine, is avoided when using chloride of calcium. It seems to pass through the pipes with less friction, and parts which were in use for a long time, showed upon removal that no corrosive action had taken place inside. Chloride of calcium also has a much lower freezing point than common salt brine, and is therefore better suited for places where a low temperature is required.—*The American Brewers' Review.*

NEW PUBLICATIONS

Illustrated Catalog of Steam Pumps No. 35, A. S. Cameron Steam Pump Works, New York, 158 pages 6 by 9 inches. This is an excellent specimen of a standard catalog. It gives full information concerning the various styles and sizes of pumps made and the special features and adaptabilities of each, with so much incidental information that the single page index might well have been doubled, even if the table of areas of circles (what catalog is without it) had been omitted.

NOTES

In 1906 the New York Edison Company, in the regular course of business, sold from its plant scrap to the value of about $200,000. The material included 632,000 pounds of copper, 359,000 pounds of lead, 71,000 pounds of mixed metals and approximately 500 tons of iron.

The rule adopted by the A. L. A. M. for estimating the horse-power of gasoline engines is to square the cylinder diameter in inches and divide the product by 2.5, which gives the horse-power per cylinder.

In drilling with piston rock drills a high pressure gives a stronger withdrawing force on the bit and tends to prevent sticking in fissured ground. In hard, tough ground, like specular hematite or certain intrusives, a high air pressure is necessary if it is desired to strike a blow, severe enough to cut the rock, with a light portable machine. In a certain mine, using 40 drills in hard and fissured ground the rock broken per machine was increased about 20 per cent. by the simple expedient of advancing the air pressure from 75 to 100 pounds.

A pneumatic jack has been designed to help in starting a large motor generator of the Edison Illuminating Company at Detroit. It comprises an air cylinder with a piston connected to an arm, this arm having a pawl engaging a ratchet on the armature shaft. The idea is

for this jack to give the armature a single impulse or kick to overcome the standing bearing friction, which is considerably higher than the running friction of any plain bearing, and also to overcome some of the inertia of the rotating parts. It is found by the use of this device that the machine can be started with a maximum current of 500 or 600 amperes, as against 1,500 amperes when it is started in the usual manner from rest.

Since a machine will drive rivets as fast as they are fed to it, the chief cost is that of handling the work. This varies with the class of work, heavy and bulky work being, of course, harder to handle. Assuming $4.50 a day for the labor, exclusive of the heater, if a machine drives some 700 or 800 rivets a day the cost for labor, power and general charges will be from 5/8 to 3/4 cent per rivet. Pneumatic hammer rivets in ordinary shop work will cost hardly less than 1½ cents per rivet for similar charges. Assuming only ½ cent saved per rivet, there is $1,000 or $1,200 saved per year. A much greater saving will generally resutt, for if double the machine rivets are driven per day the cost per rivet is practically cut in half.

Liquid air promoters are endeavoring to interest capital in the establishing of liquid air producing plants, as at Richmond, Va., where demonstrations of the interesting properties of this exceedingly cold but perfectly dry liquid were given. The claims of the promoters as published in the local papers and widely copied are, however, misleading. The enormous saving claimed by substituting liquid air for ice in refrigerator cars is still a matter that needs to be demonstrated. The statement that the promoters were making liquid air at a cost of $44 for 140 gallons also is misleading. That would be over thirty cents per gallon, while Mr. Bobrick at Los Angeles, Cal., has been making it for a number of years at less than ten cents per gallon, and claims he can make it for one cent per gallon and store it for nearly thirty days.—*Ice and Refrigeration.*

Dr. Joseph A. Holmes, in Bulletin 333 of the U. S. Geological Survey, says that experience in the deeper and more dangerous coal mines of Belgium and other countries not only indicates that American mine accidents may be reduced to less than a third their present number, but also gives promise of their practical prevention. The coal mining methods of America are less safe than those of any other country. Over two thousand men were killed and five thousand more were injured in our collieries during 1906. This was 3.4 men killed for every thousand employed. In Belgium in 1906 the number was 0.94, in Great Britain it was 1.29, in France it was 0.84 in 1905, and in Prussia it was 1.8 in 1904. The number of American coal miners killed and injured in 1906 by different causes is stated as follows: Gas and dust explosions, 228 killed and 307 injured; powder explosions, 80 and 215; falls of roof and coal, 1,008 and 1,863; other causes, 732 and 2,192. What makes these figures more shocking is Dr. Holmes' further statement that in no other country in the world are the natural conditions so favorable for the safe extraction of coal as in the United States.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JANUARY 7.

875,787. FLYING OR AIR CAR. SELDEN A. DAY, Paris, France.

875,869. ROCK-DRILL. ROLLAND S. TROTT, Denver, Colo.

875,942. ACETYLENE-LAMP AND LIGHTING DEVICE FOR AUTOMOBILES AND OTHER VEHICLES. SVEND M. MEYER, New York, N. Y.

875,957. THERMOSTAT. OLAF SAUGSTAD, Plainfield, N. J.

875,958. VALVE FOR FLUID-PRESSURE BRAKES. WILLIAM H. SAUVAGE, New York, N. Y.

876,066. AUTOMATIC FLUID-PRESSURE REGULATOR. ARCHIE KLEVER, Hannibal, Mo.

876,068. RIVET-CUTTER AND PUNCH. CONRAD H. LAU, Renova, Pa.

876,119. ACETYLENE-GAS GENERATOR. WILLIAM J. WALSH, Ferris, Tex.

876,125. FYLING-MACHINE. FRANK WONDRA, Schenectady, N. Y.

JANUARY 14.

876,359. PRESSURE-REGULATOR FOR COMPRESSED-GAS PLANTS. LOUIS KARGER, Ehrenfeld, Germany.

876,371. PNEUMATIC BRUSH. FRANK J. MATCHETTE and CHARLES MOUKOS, Milwaukee, Wis.

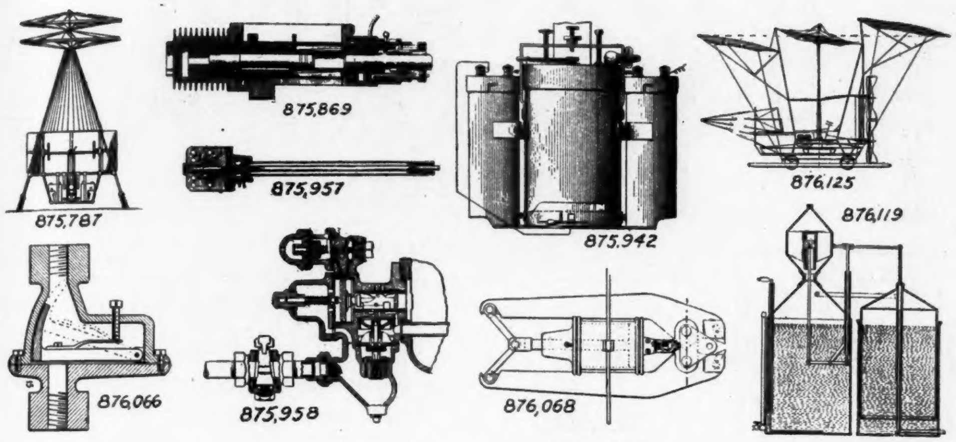
876,374. HOT-AIR ENGINE. ALPHONSE MAYR and JOHN WALLACE, Bombay, India.

876,422. ELASTIC-FLUID TURBINE. JAN ZVONICEK, Brünn, Austria-Hungary.

876,426. PNEUMATIC SUSPENSION DECIVE FOR VEHICLE-BODIES. GEORGE W. BELL, Liverpool, England.

876,460. STARTING MECHANISM FOR INTERNAL-COMBUSTION ENGINES. HOWARD A. JOHNSON, Toronto, Ontario, Canada.

In an internal combustion motor the combination of a storage air tank; a second tank; a pipe connecting the two; a stop cock in said pipe; a pipe connecting the second tank with the cylinder of the engine; a pressure limiting valve in said pipe; and a stop cock between the pressure limiting valve and the second tank, substantially as described.



PNETMATIC PATENTS JANUARY 7.

876,757. APPARATUS FOR PRESERVING EGGS. HANS J. WINTHERLICH, Omaha, Nebr.

In an apparatus for preserving eggs, the combination of a receptacle, means for supporting eggs therein, a vacuum producing means connected with the receptacle, means for subjecting the receptacle and contents to heat for opening the pores of the eggs and killing the germs, and separate means for supplying antiseptic and sealing solutions to the receptacle.

876,827. CAISSON CONSTRUCTION. ALEXANDER Z. MCLEOD, New York, N. Y.

876,848. PUMP OPERATED BY COMPRESSED AIR. DANVILL W. STARRETT, San Francisco, Cal.

876,849. PUMP OPERATED BY COMPRESSED AIR. DANVILL W. STARRETT, San Francisco, Cal.

876,859. PNEUMATIC CARRIER. MAJOR R. COLLINS, Indianapolis, Ind.

JANUARY 21.

877,043. VALVE OPERATED BY AIR. JAMES BOWES, Caldwell, N. J.

877,102. PRESSURE AND SUCTION BLOWER. WILLIAM J. MAGEE, St. Louis, Mo.

877,142. MEANS FOR INCREASING AND PROMOTING THE COMBUSTION OF FUEL. GEORGE R. TORREY, Washington, D. C.

In an apparatus of the character described, a furnace, a fire-chamber, a bridge-wall, a vortex chamber within the bridge-wall for giving a circular, centrifugal action to steam and air, and means for forcing said steam and air into and through the fire chamber of the furnace.

877,162. APPARATUS FOR CONSUMING GAS. FRANK W. BEARDSLEY, New York, N. Y.

877,203. PNEUMATIC MUSICAL INSTRUMENT. EUGENE DE KLEIST, North Tonawanda, N. Y.

877,234. ACETYLENE-GENERATOR. SAMUEL W. RUSHMORE, Plainfield, N. J.

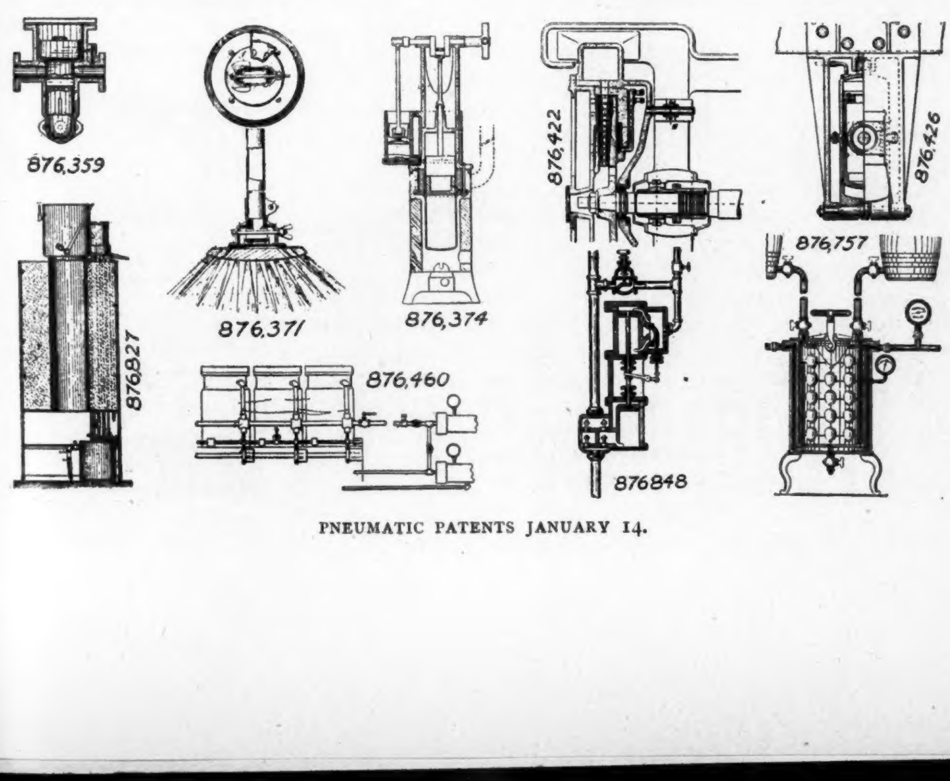
877,308. PNEUMATIC CAISSON. OLIVER C. EDWARDS, JR., Rensselaer, N. Y.

877,369. ELECTROPNEUMATIC MACHINE. WILLIAM K. RANKIN, Philadelphia, Pa.

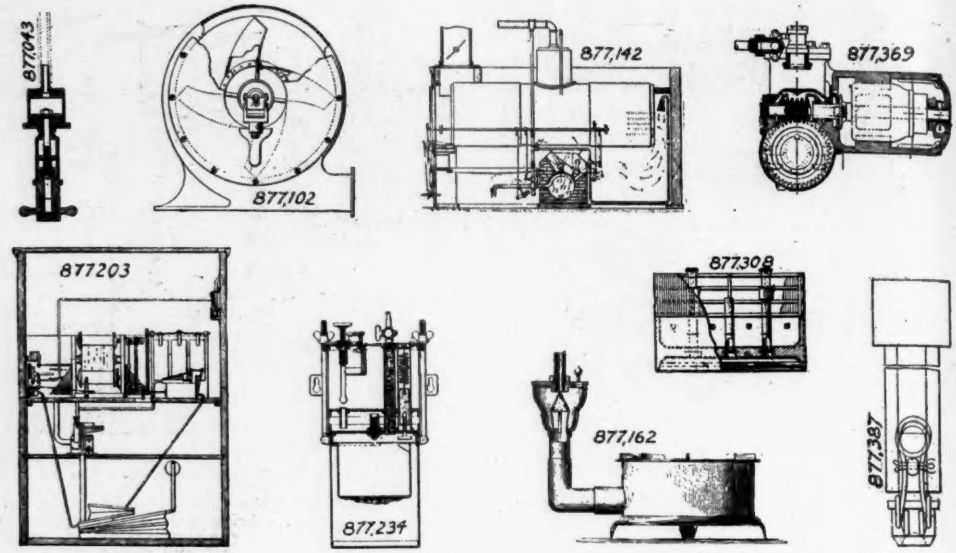
877,387. SAFETY-SPRING FOR STEAM AND COMPRESSED-AIR HAMMERS. WILLIS F. WALKER, York, Pa.

877,447. PROCESS FOR THE PRODUCTION OF PURE NITRIC ACID. HARRY PAULING, Gelsenkirchen, Germany.

The herein described process, consisting in subjecting atmospheric air to the action of electrical discharges, mixing the nitrogenous gases, thus formed, with water or aqueous vapor while the said gases have



PNEUMATIC PATENTS JANUARY 14.



PNEUMATIC PATENTS JANUARY 21.

a minimum temperature of 200 degrees C., and cooling down the mixture, as set forth.

JANUARY 28.

877,520. FLUID-COOLING APPARATUS. PAUL SCHMALTZ, New York, N. Y.

877,523. PNEUMATIC DRILL. JOHN W. SMITH, Philadelphia, Pa.

877,529. AIR-SHIP. PETER T. TKATZSCHENKO, Schenectady, N. Y.

877,530. AIR-BRAKE. WALTER V. TURNER, Wilmerding, Pa.

877,557. AIR-SEPARATOR. GEORGE S. EMERICK, Nazareth, Pa.

877,707. AUTOMATIC SPRINKLER SYSTEM. JAMES FIDDES and JOHN F. WATT, Aberdeen, Scotland.

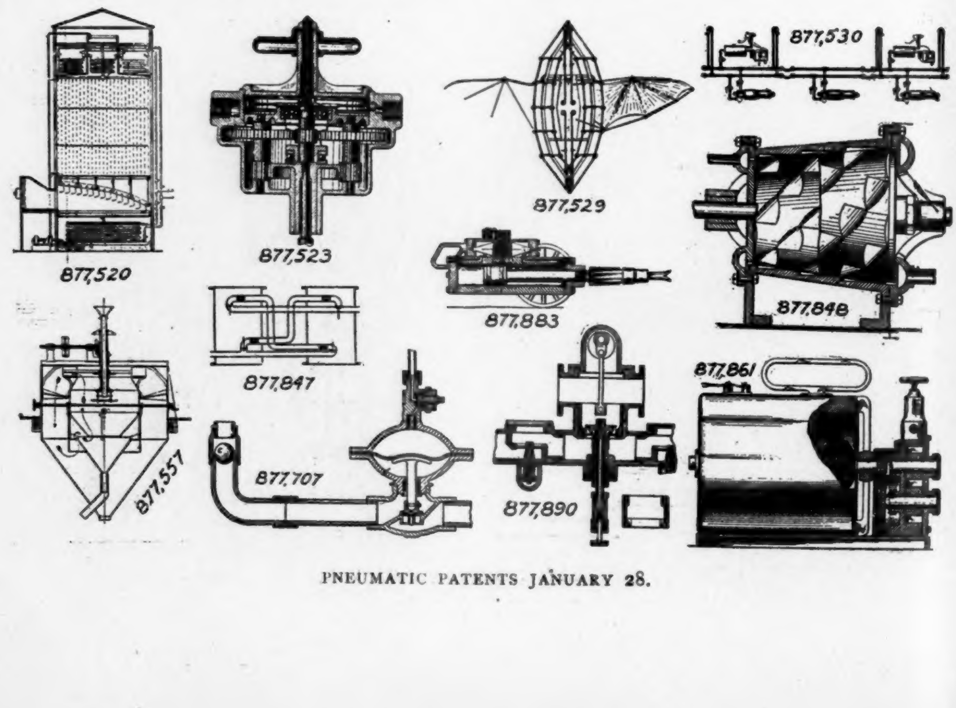
877,847. FLUID-PRESSURE ENGINE. HUGO LENTZ, Hallensee, Germany, and CHARLES BELLENS, Neuilly-sur-Seine, France.

877,848. FLUID-PRESSURE TURBINE. BENJAMIN E. LEWIS, Palouse, Wash.

877,861. PORTABLE TIRE-INFLATER. JOHN W. RADU, Rochester, N. Y.

877,883. PNEUMATIC MINING-MACHINE. WILLIAM B. BUTTS, New Philadelphia, Ohio.

877,890. VAPORIZER. GEORGE H. GERBER and ALFRED WEILAND, Reading, Pa.



PNEUMATIC PATENTS JANUARY 28.